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QUARTERLY

OF THE

National Fire Protection Association

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87 MILK STREET, BOSTON, MASS.

EDITED BY THE SECRETARY

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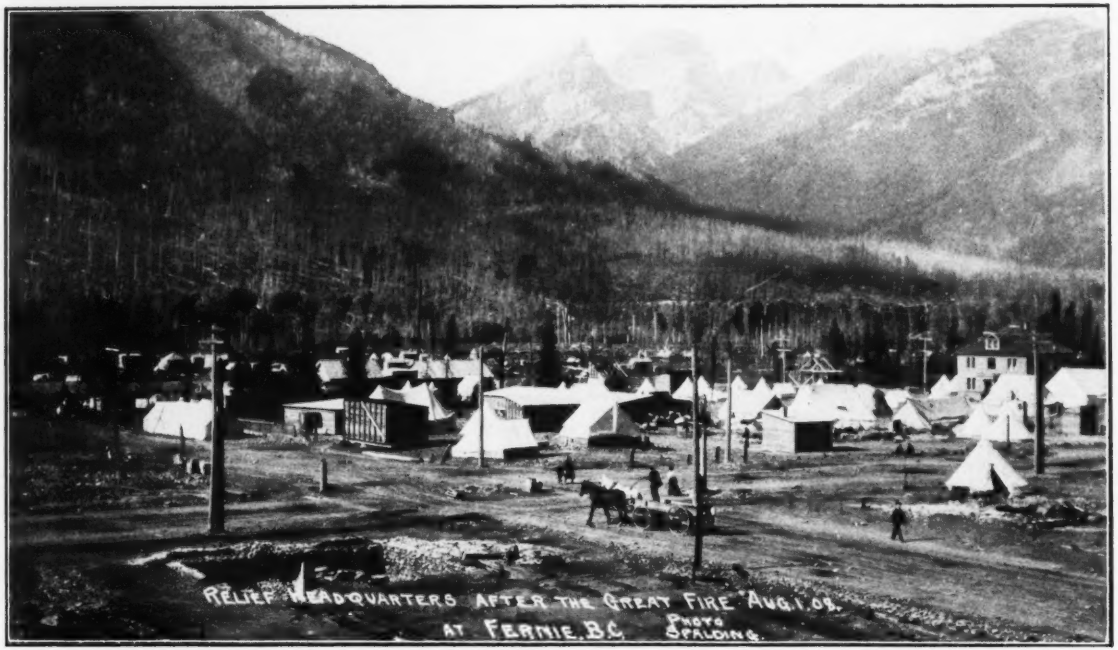
Reports on fires appearing in the Quarterly are copies of or extracts from written reports forwarded to the Association. This Association, as a body, is not responsible for the statements or opinions of any of its members.



See "Forest Fire Waste in Canada."

"To develop property and not preserve it;
to accumulate wealth and not protect it!"

The Quarterly

Vol. 6 **October, 1912** **No. 2**

Fire Department Inspections.

There is no brighter star above the horizon of our hopes than the rapid development of the municipal fire department as an instrument of conservation. All these many years of our pitiful burnings we have held one of our most powerful weapons indifferently in abeyance. Our firemen have gone to their death year after year in fires that never would have happened had firemen been encouraged and empowered to prevent them. Efficient fire chiefs have always made inspections, but when, three years ago, we began our campaign for inspections by the rank and file of fire departments, a new and tremendous energy was brought into play. The response by the firemen has been enthusiastic. The work has recreated and interested them. We are told that several of the Cincinnati firemen have been known to forget their luncheons, absorbed in their new work. The Fire Prevention Bureau of the Chicago fire department, following so soon after the establishment of the similar bureau in New York City, sets this important innovation in municipal conservation prominently before the country, and the fire departments of the smaller cities and towns are rapidly taking up the work. Methods vary somewhat in the conduct of it. In some cities inspections and re-inspections are made by the same men, in others different men make the re-inspections, thus checking each other up. In some cities only a certain district, or a specific class of buildings is inspected, in others everything except residences, and in some even residences are visited. Our valuable Newark, N. J., member, Captain Albert Gasser of the Bureau of Combustibles and Fire Risks, has this to say on the subject in a letter to *Fire Prevention*:—

> The Bureau of Combustibles now includes five members of the regular department, detailed to the Inspector of Combustibles permanently. These men wear the words "Fire Prevention" in silver letters on the left sleeve of their uniforms; an idea original in this office but recommended for adoption by every progressive community. This insignia opens the doors and paves the way for many important interviews. The factory superintendent realizes without argument the mission of his uniformed visitor.

Within a month of the creation of this Bureau, March 15, 1907, an order was issued by the chief engineer that every factory building was to be inspected by members of the department, each company to inspect buildings within its own fire hydrant district. These inspections were made according to blanks furnished by the Bureau and called for a drawing or diagram of the inspected building in addition to such facts as are being collected at this time by the Cincinnati department.

When all the buildings had been gone over (something like two years having elapsed) a new record blank was furnished and the inspections were continued according to the new blanks which were on cards. The idea was to break the monotony in the minds of inspecting firemen. We are about finished with these cards and then another style will be adopted.

These series of inspections reveal actual conditions. It is then a simple matter to send a specially trained fireman from this office to make a reinspection of hazardous conditions, to make recommendations, to talk to owners about fire dangers and to spread the gospel of fire prevention. We offer our services to manufacturers to help them. We make it known that we are not so intent upon the enforcement of laws and ordinances as we are upon common-sense regulations to safeguard lives and property.

There are really no practical difficulties in the way of members of a city's fire department making inspections.

* * * * *

Fire Prevention Day. While the municipalities are contributing fire department inspections as a manifestation of their interest in checking the fire waste, the states are rapidly establishing Fire Prevention Day. Thirteen observed the day last year and one new state, Oklahoma, has been added to the list. This is a sort of basic education, for it reaches back to the child. George Eliot said that there have been no great peoples without processions; meaning, probably, that processions are a barometer of the intensity of the civic spirit. Peoples are great as they manifest unity, and a common aim is registered in a public demonstration. Individual selfishness never makes a public demonstration; or, if it does, it gets into jail.

Mrs. O'Leary's cow, led gravely in the Chicago procession, opening her wide, bovine eyes in wonder at her unfamiliar surroundings, rises to the dignity of an idea. The child sees her and asks what she is there for; the story of the Chicago conflagration is rehearsed, and the lantern becomes a symbol of fire hazard, to be guarded against overturning.

It is natural that the middle states should choose October 9th for their fire prevention demonstration; as the Pacific coast might be expected to select April 18th, the anniversary of the San Francisco earthquake and fire, and the Southeastern states the anniversary of the conflagrations of Baltimore or Atlanta,—local experiences, common to many people, are the fertile soil from which spring suggestions for celebration ideas. The cities which have suffered the most disastrous fires are richest in the incidents which may be recreated in pantomime and procession. Any city, however, with live men and women in it, can plan and execute a fire prevention day that shall interest and instruct and carry salutary lessons to grown-ups as well as children.

London's Post Office Fire. Everybody knows what a pitiful old fire-trap the general post office of New York city is, but evidently no one in the English metropolis prior to Saturday night, August 24th, had ever dreamed the London post office was vulnerable. If anybody had, every possible means would have been previously taken to insure its safety from the ravages of flames. The British government owns the telegraph and telephone systems, and uses the general post office as a clearing house for these utilities. All the main cables for provincial towns and the wires connecting with foreign cables concentrate there, hence the complete paralysis of the system when the fire broke out. The English telephone service is remarkably primitive compared to that of America and other civilized countries, and it was immediately bombarded by violent newspaper criticism because of the predicament in which the press throughout Great Britain was left by the disaster. All the cable and telegraph wires underneath the floors had fused, and the firemen were obliged to tear up the floors in order to get at the seat of the flames. This was not resorted to, however, until an effort to stifle the flames by the use of sand had proved ineffectual. Fortunately the building sustained no structural damage, but otherwise the loss was exceedingly heavy. It is well understood that the destruction of the building would have paralyzed the commercial world, hence it is more the wonder that such a calamity should be possible. As derelict as the United States is accused of being, it is wise enough not to concentrate all the most important and dependable agencies at one central point where they would be threatened by fire.

It was only by means of the most strenuous exertions that even temporary repairs could be made, and arrangements be so ordered that communication could be sufficiently restored to enable the United States and Canada to receive the enormous amount of press matter that is sent by cable to this continent. It was accomplished only by dispatching automobiles to Penzance and Cornwall and those other cable offices that lay on the direct route of the various coast points to which cables are laid. Many thousands of words had been thus dispatched, when about 10 o'clock p. m., three hours after the fire had been discovered, temporary repairs were made and communication with America was restored.

The building in which the fire took place was not originally erected for post office business, but was of a group added to meet the necessities arising from the increase of business and the additional accommodation needed for the telegraph and telephone apparatus, operators and clerks. The group consists of three buildings, the eastern (the original general post office structure erected in 1825–1829), the north and the west buildings, connected by a bridge. In the latter are the main portions of the telegraph department, in which is a long gallery with a floor space of 300 by 90 feet, on which are 500 telegraph instruments. The western building receives the overflow from the telegraph department, and in it are also located the administrative and official offices. It is safe to assume that our English cousins will take the steps necessary to avoid any repetition of their predicament.

Railway Locomotives as Fire Engines. Railway locomotives were equipped as fire engines by the Pennsylvania Railroad more than ten years ago, and during this period have made a remarkable record in extinguishing fires, not only on its own property, but in rendering timely assistance at fires along the road, often in out-of-way places where there is no other protection to be had. This form of protection has been developed until to-day the Pennsylvania has 62 engines in yard and switching service equipped with this special apparatus and supervised by a well organized private fire department at all of its larger terminals, which is in addition to systems of water mains and fire hydrants at these points.

The original arrangement, which consisted of a hose connection placed in the line conveying water from the injector in engine cab to the boiler, has been improved by providing a special form of extinguisher, by which the water from the locomotive tender is discharged through the ejector by means of the high steam pressures carried in locomotive boilers. Based on a series of tests, the standard equipment for each locomotive consists of 150 feet of two and one-half inch unlined linen hose and a fifteen inch cast iron nozzle with a discharge opening of five eighths of an inch, kept in a box under the running board of the engine, the hose being coiled in separate sections. With this equipment engines are enabled to throw a stream of water seventy feet.

The yards are divided into districts, each of which is designated by a number. When a fire is discovered, a general alarm calling all engines in the particular district is sounded on air whistles installed on each switch tower. By a code of signals engineers and firemen of locomotives can tell immediately just where the fire is. To insure a prompt response yard masters and train directors are instructed to give the locomotive clear track in reaching the scene of fire, and in cases where locomotives are moving or shifting cars, the crews are instructed to uncouple the engines and proceed without delay to the fire immediately upon the sounding of the alarm, on the way to the fire connecting up the hose and preparing to get into service immediately upon arrival.

The locomotive fire brigade organization in each yard is under the general supervision of the assistant yard master acting as chief, and co-operates at all fires with the regular yard fire brigade, which is organized and regularly drilled at each point. The conductor of the shifting crews is designated as captain, and has direct charge of his own crew in all fire operations. To each member of the crew is assigned a special duty—to the flagman the unreeling and laying of hose line and making connections; to the two brakemen the moving of the hose line and directing the nozzle; to the engineer and fireman the operation of the pump and maintaining the required pressure.

One of the great advantages in having these fire equipped locomotives is the fact that they are always "on the ground" ready for immediate service, and affording protection for yards, which, in many instances, would not be accessible to outside fire departments. By careful supervision and frequent drilling the crews become expert in fire fighting. An example of the

efficiency of these organizations is shown in response to a fire exposing a gas tank under a passenger car. Here the first engine was coupled up ready for service within two minutes after the sounding of the alarm, while within seven minutes nine engines were on the scene.

During 1911 the record shows that these locomotives extinguished forty-nine fires, and in the last four years 153.

* * * * *

Shingle Roof Legislation. Massachusetts being the birthplace of the N. F. P. A. naturally desires to be a leader in all things relating to fire prevention, but leadership in almost any direction is generally more or less of a lonesome job.

Brookline, Mass., has taken a referendum vote, as the result of which the use or construction of the shingle roof is prohibited in the town, but the vote in favor of the abolition was only eighty greater than that opposed, showing a large strength of public sentiment arrayed against the march of improvement and its own safety. With the conspicuous example of Chelsea's fate only next door and so short a time in the past, the close vote at Brookline seems to indicate that this fashionable suburb contains enough citizens opposed to the public welfare to make the new ordinance difficult of enforcement. When Secretary Wentworth of the N. F. P. A. was a councilman in Salem, Mass., his ordinance prohibiting shingle roofs was defeated twenty-three to one; and there were twenty-four members of the council. Somerville, Mass.; has had such an ordinance for several years requiring that when a roof is repaired to the extent of one third of its area it shall be replaced with fire retarding material, and has stood steadfastly against the onslaughts that the lumbermen have made to repeal it. It has recently, however, been cracked over the head by the Massachusetts supreme court for being so progressive. A man named Hayden reshingled a building in defiance of the common welfare and the city ordinance and the city prosecuted him for the offense. In the superior court he was naturally found guilty by a jury. The trial judge granted delay of execution, and Hayden, either to gratify his own anarchistic instincts or to serve some private interest opposed to the welfare of his neighbors, appealed to the supreme court on exceptions.

The exceptions set up that the building was not made more hazardous, that it was not a nuisance, that the ordinance is unreasonable and not within the lawful exercise of police power of the city and is an unwarranted delegation of power to the officer (inspector) and in violation of the Constitution of Massachusetts, Article 10.

The state was enabled to step in through Chapter 104, Revised Laws, Sections 1 and 10 and the important difference in the wording of these two sections, No. 10 including "repairs" and Section No. 1 making no mention of repairs, and it was through this hole that the court, with the aid of the dictionary, pulled Mr. Hayden.

The rescript was sent down "Exceptions sustained" (on which par-

ticular ground does not appear: perhaps because of "unreasonable and unwarranted delegation of power").

The decision of Chief Justice Ruff is worded as follows:—

> The reshingling of a roof theretofore shingled does not come within the enumerations of the Statute.
>
> Reshingling is simply a *repair* of an existing structure.
>
> It is not a "construction," which means the erection of a new building or an addition to an old building.
>
> "Alteration" denotes a change or *substitution* in a substantial particular of one part of a building for a building different in that particular.
>
> "Use" indicates the purposes for which the building may be occupied.
>
> "Materials" is a word of general significance and must be interpreted as auxiliary to the other more definite terms of the Statute.
>
> There is no word in the section of the Statute which properly construed comprehends *repairs* upon buildings.
>
> A criminal statute is not to be enlarged beyond its plain import.
>
> Under Section 10, same Statute, the owner of an *unsafe* building might well be denied the right to repair when the same right would not be withheld from the owner of a *building sound* and capable of prolonged use with suitable repair.

In Massachusetts the municipalities can assume no powers regarding their own affairs that are not expressly delegated by the state. The state legislature meets every year from January to June, for the purpose of revoking the laws passed the year before, or taking out the "jokers." It is to be hoped that the new Metropolitan Fire Hazard Commission, appointed at the last session, may find some legal way for the people of the wooden cities of the state to legislate for their common safety without being balked by the courts.

* * * * *

Asbestos Roofing. Writing in *Fire and Water Engineering*, Ralph B. Wade gives high praise to combinations of asbestos and asphaltum in roofings. Referring to the desirability of a scientific combination of materials that shall furnish both time-proof and fire-proof qualities, he says:—

> The selection of a composite, all-mineral roof covering adaptable to any class or style of structure, which combines naturally the above mentioned requisites for ideal results, is found in the built-up asbestos roof, a combination of Trinidad lake natural asphalt (mineral) and pure asbestos felts (stone). Everyone is familiar with the ordinary street pavement, which is approximately ninety per cent mineral (crushed rock) and ten per cent asphaltic binders. The lake natural asphalts are recognized as the most lasting water and weather proof binder for the composite mineral pavement. This is due to the extreme stability and ductility of Trinidad asphalt which has in its natural state resisted for untold centuries the destructive weather conditions of the tropics. Asbestos felts, ninety-five per cent pure (fibrous material), weighing not less than fifteen per cent to the square, are impregnated with Trinidad asphalt, completely coating each fiber, and filling absolutely the minute interstices in the asbestos fiber. Asbestos felts are non-tubular, and therefore have no capillary attraction. The exposed roof surface is finished with an unimpregnated sheet of pure asbestos felt, completely sealing from the action of the sun the asphalt below in the impregnated plies and the moppings of asphalt between the plies. Therefore the asphalt impregnation is permanent and cannot

be drawn out by action of the rays of the sun, which quickly destroy and oxidize the asphalt saturation in wool felts through capillary attraction. This complete protection of the asphalt, the waterproofing agent of the roof, is of vital importance, as far as regards eventual upkeep expenses connected with the finished roof; eliminating entirely the costly renewal of waterproofing by painting, absolutely necessary wherever wool felts saturated are exposed to sun attack. The white surface reflects the sun's rays to a surprising degree, reducing the temperature of the roof fabric from eighteen to thirty degrees in hot weather. This feature is, in itself, important, aside from the resultant cooler building, insomuch as ordinary asphalts in common use have a melting point of approximately 135 degrees, at which temperature they lose their binding, cementicious qualities entirely. Such a temperature is often reached on the surface of a roofing fabric exposed to direct sun heat during the summer months. The most commonly known property of asbestos is its imperviousness to destruction by fire, and it has been demonstrated many times that fire cannot get through an asbestos roof from the surface. Internal fires will not affect it until roof boards are entirely consumed, allowing the roofing to fall. Asbestos roofing applied directly over a concrete roof slab will waterproof and finish with an indestructible weather covering the modern absolutely fireproof structure.

* * * * *

Chimneys and Flues. The N. F. P. A. bulletin on *chimneys and flues* issued by the secretary last month, met with overwhelming approval by the members. Many orders for large quantities were received and a multitude of requests for small quantities from all parts of America. The southern states seem to be the principal offenders in poor chimney building, due probably to the mildness of the climate. In the north hot fires are imperative over long periods, and a poor flue gives trouble the first winter. Our Wisconsin member, Fire Marshal T. M. Purtell, has just sent us his compilation of fire causes in Wisconsin during the twelve months ending June 30, 1912. Out of 624 fires, 239 were due to defective chimneys; 108 to stoves too near wood, and 90 to stovepipes too near wood. Sparks from chimneys (shingle roofs) is the next highest, with 67 fires. The monetary losses were from the chimney fires, $204,440; from the stoves, $95,140; from the stovepipes, $51,765, and from the chimney sparks, $35,075. If a state like Wisconsin, noted for its progressive spirit, shows a record like this, the complete statistics for the country would be staggering.

Mr. Robert D. Kohn of our executive committee, one of the leading American architects, does not favor the provision of an ash pit at the base of a chimney. In a letter to the Secretary he says:—

> Personally I make it a practice to omit ash pits, and I doubt if they are of any value at all from the point of view of fire. They are frequently unused, and I have found them stuffed with rubbish and in at least one case found it converted into a heat flue from a hot air furnace without proper protection. If ash flues were constructed the same as a fire flue it might be safe, but as they are supposed only to hold ashes they are carelessly built, are unlined, may afterwards be converted to another use, and are therefore dangerous.

Mr. Kohn also refers in complimentary terms to the growing use of the reinforced concrete slab as a substitute for brick in the trimmer arch of the fireplace designed as a support and safeguard for the hearth:—

This is quite common now in this part of the country (New York). A wood form is put in between the header beams and the brick chimney so as to form a center for a slab that rests on yellow pine cleats or angle iron plates around the hearth opening and a brick corbel on the chimney side. Any light galvanized wire mesh can then be laid in on top of the form and a 1-2-5 mixture of cement, sand and stone or cinders poured in. This makes a splendid foundation for the hearth and has the advantage that it cannot fall through settlement except it fall in one piece.

Another valued New York member of the N. F. P. A., ex-chief Edward F. Croker, gives interesting practical advice as to how a chimney fire may best be extinguished:—

Water should not be used to extinguish fire in a chimney flue, as it is liable to burst the flue or cause the chimney wall to crack; neither should a brick or such other article which would be liable to get caught in the flue be used. To properly extinguish fire in a chimney flue, all the openings to the flue below the roof should first be closed tightly, so as to prevent the falling soot from flying about the rooms or premises and doing unnecessary damage. Then a bag of salt, a pail of small coal, or a pail of sand, or other similar substance, should be dumped down the flue opening at the roof. Salt extinguishes a chimney fire quickly by chemical action, when it comes in contact with the fire, and coal or sand will carry the soot down to the bottom of the flue, where it can be removed. Chemical powders, composed chiefly of bicarbonate of soda or similar salts, are very good with which to extinguish fire in a flue, and should be used by throwing a handful up the opening at the bottom and then closing it to prevent the soot from falling and scattering about. An ounce of sulphur, lighted and placed in a stove, or at the bottom of a flue that is on fire, will quickly extinguish the fire with the fumes that ascend from it. Another good method to extinguish a fire in a chimney flue, where it is desired to remove the soot, is to get a dozen pieces of chain eight or ten inches long and with one-half or three-quarter-inch link, tie them closely together with wire, then attach to them a piece of the same kind of chain about ten feet long and enough clothesline to reach from the top to the bottom of the flue. The bunched chain should then be dropped down at the top of the flue and pulled up and down several times, after which the fire will have been extinguished and all the soot will have dropped to the bottom. All openings to the flue at the bottom and below the roof should be closed up tightly in this case, also before dropping the chain, and they should not be opened until the soot has settled, after which it should be removed gradualy and carefu'ly so as to prevent it from flying about and causing unnecessary damage. A blank pistol shot fired upward from the bottom of a flue in which there is fire or soot will loosen the soot and bring it down to the bottom, but this is not advisable as the falling soot is liable to scatter about. A small fire cracker lighted and dropped down at the top of the flue is much better and less dangerous, but all openings to the flue below the roof should be closed when the latter method is resorted to.

Putting out a chimney blaze with a pistol or a fire-cracker is a method of fire prevention sufficiently interesting and dramatic to prove attractive to the youthful male members of the household.

* * * * *

Coal Oil in Cotton Bale Fires.

Mr. E. B. Berry of Washington, D. C., one of our members on the inspection staff of the Southern Railway Company, writes us as follows:—

Reading with interest the report from "Missouri" under paragraph headed "Coal oil as a fire extinguishing agent," page 393 of the April QUARTERLY:—

Unless it can be established beyond question that coal oil will extinguish a fire located inside of a bale of cotton, the information is not only misleading but may be conducive of a large fire loss.

In adjusting a cotton loss at Russellville, Ala., investigation developed brokers of that town had used coal oil to extinguish the fire. To be more accurate, fifteen gallons of coal oil were poured into each of two bales on fire. Apparently the results were satisfactory, but during the night both bales were totally destroyed.

I realize the aforesaid mentioned paragraph was only offered as evidence without reference to its truth or falsity, but appearing in a periodical emanating from a source conceded by the field forces to be the fountain head of fire research, it would seem consistent to ask for more detail and specific information regarding coal oil as a fire extinguishing agent in cotton fires.

Mr. Berry is correct in his assumption that we did not print the original paragraph as a recommendation for members to follow. There is no doubt that though the oil treatment worked successfully as an extinguishing agent in the Missouri case, it might easily fail in another; just as water might extinguish a fire at one time and not at another. One member says that oil did extinguish such a fire; another reports the experiment a failure. The member first reporting refers to the oil treatment as a "last resort," before picking the bale to pieces. As the oil cannot be followed by the eye to the seat of the fire, its use is an act of faith, which, as Mr. Berry says, may be expensive. The sure way is manifestly to distribute the bale.

* * * * *

The State Fire Prevention Associations. Our active members, the State Associations, have been busy during the summer months, especially those in the northern tiers of states, where inspections are more comfortably carried on in summer than in winter. In almost every state, in which there is an efficient fire marshal, great team work is being done by the latter and the committees of the State Associations. In certain states the laws need revision to give the fire marshal requisite power. In the states where the power is granted, the old wooden rookeries are coming down. Mr. Joel W. Hubble, of Illinois, originally appointed chairman of the N. F. P. A. committee on State Fire Prevention Associations, having been promoted to the managerial class, has resigned the chairmanship, his brother, Mr. John P. Hubble of Kentucky, being appointed chairman by the executives. Mr. John P. Hubble has already rendered great service to the cause of fire prevention, and the executives believe that the State Asssociations Committee will become a very effective instrument in his hands.

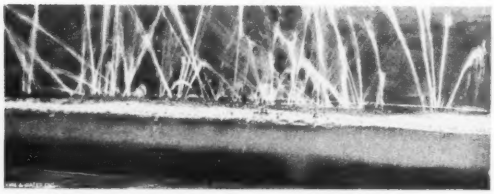
* * * * *

The International Association of Fire Engineers. The present year has heralded such a movement for fire prevention among the fire chiefs as to bring us into much closer fellowship with our active member the International Association of Fire Engineers than ever before. Chief Stanton, of Norwich, has been active in our committee work for a number of years, but this year has added four

other well-known fire chiefs to our working staff: Chief Bennett, of Birmingham; Marshal Bringhurst, of Seattle; Chief Kenlon, of New York; and Chief Loller, of Youngstown. The fortieth convention of the Fire Chiefs, just over at Denver, makes the N. F. P. A., with its sixteen years of life, seem a stripling by comparison.

The past year has seen the fire chiefs' organization recognized by the government of the United States, in that the Association's president, Chief Loller, was named by the Secretary of State as the United States' delegate to a foreign firemen's congress. A declaration by resolution that building inspection by uniformed firemen is the surest way to bring about effective fire prevention, adopted by the Chiefs without a dissenting vote, was the feature of the first day's session of this year's convention.

The "Firemen's Friend" Brand.



Bursting Fire Hose.

When a fireman goes into a burning building with a line of hose, it is a great comfort to him to know, if the hose bursts and he is left without water and compelled to jump for his life, that the hose is guaranteed and will be replaced by those who sold it.

Public Education.

The campaign of public speaking has as usual been somewhat suspended during the summer months and the vacation periods, although a few addresses have been delivered by our members at such conventions or other gatherings as choose the summer months for assembling. The Secretary's office has, however, been busy in the preparation of publications, which have already been mailed to the membership or are to be mailed shortly. The special bulletin on *Chimneys and Flues* promises to be the most popular piece of campaign literature ever issued by the Association. Orders for the same already amount to many thousands and requests are still being received not only from remote points in the United States and Canada but from members in foreign countries.

The Committee on Private Fire Departments and Fire Drills has completed its painstaking labor in compiling its pamphlet on *Exit Drills*. This is also a work which has found great favor with the membership. This committee has also completed its revision of the pamphlet on *Private Fire Departments*, which has been passed upon by the Executive Committee and recommended to the National Board of Fire Underwriters for printing.

The revised report of the Committee on *Fire Hose* has been attractively printed and widely circulated. It is certain to be of very great assistance in the educative campaign to prevail upon the muncipalities of the country to purchase fire hose made according to national standard specifications.

The Committee on Laws and Ordinances has completed its important work in the revision of the measures referred back to it at the annual meeting. These measures are an ordinance providing for the care and inspection of premises by the fire department; a state law regulating the manufacture, storage, etc., of matches; a city ordinance on the same subject; and two laws and two ordinances governing the handling, sale, storage and transportation of explosives. These ordinances represent a very great labor on the part of this committee, and their wide distribution is sure to have a very salutary educative effect.

Beside the above publications the *Year-Book and Membership Directory* for the current year has been prepared and forwarded to members. The work on the same this year was especially arduous because of the consolidation of the two classes of membership, the associate and subscribing, into one class.

From the above, it is obvious that the output of literature has been considerable even if the public speaking has been abated by the summer season.

Mr. Henry C. McCain, Secretary of the Arkansas Fire Prevention Association, delivered a very interesting address before the Arkansas Advancement Association on the need of united effort to lessen the annual fire waste. Mr. McCain suggested methods of co-operation by which those influential in Arkansas business circles might save the citizens of that state at least two million dollars per year.

* * * * *

Mr. W. E. Mallalieu, General Agent of the National Board of Fire Underwriters, attended this year for the first time the annual convention of the Fire Marshals' Association of North America. The meeting was held at Detroit and Mr. Mallalieu delivered an address advocating the adoption of a uniform fire marshal law. Mr. Mallalieu's recommendation was received with favor by the convention and was referred to a Committee on Laws and Legislation to be appointed by the President to be reported to a special meeting of the Association to be held probably in November prior to the meetings of the state legislatures.

* * * * *

The matter of the reduction of the fire waste received considerable attention at the annual meeting of the Trans-Mississippi Congress held in August at Salt Lake City. The principal speaker on this subject was our member the Honorable Willard Done, Insurance Commissioner of Utah. Mr. Done's address was acknowledged to be one of the best at the meeting. His activity in fire prevention has been of great aid to the work of our association in the West.

* * * * *

Our Newark, N. J., member, Captain Albert Gasser, has placed in the factories and the largest office and residence buildings of his city, specially prepared cards on which are given instructions for action to be taken immediately in case of fire. Over three thousand factories and other buildings have already been furnished with these cards. Captain Gasser is indefatigable in his fire prevention work.

* * * * *

Mr. Richard L. Humphrey, a member of our executive committee, speaking before the International Congress of Testing Engineers in September gave the New York politicians a sound scoring for their interference in the engineering problems of the metropolis. The occasion of Mr. Humphrey's criticisms was the tampering with and emasculation of the new city building code into which a number of our members put so much of painstaking labor. Mr. Humphrey did not criticise the New York building department, but contended that the politicians of the city council had prevented the new buiding code from being the most up-to-date of any in the world.

Secretary Franklin H. Wentworth made a most successful visit to the province of Nova Scotia in August, appearing as a speaker at the seventh annual convention of the Union of Nova Scotia Municipalities. The convention was held in the interesting little city of Antigonish, and although the attendance was not large, the value of the same was incalculable, as the fifty odd gentlemen present were all mayors, wardens, aldermen or other officials of Nova Scotia cities. Secretary Wentworth was able to point out to them the fact that although their cities were almost wholly wooden, it would be impossible for one to go to the relief of another because of the difference in the character of their hose couplings and hydrant fittings. At the conclusion of the interesting and animated discussion by the city officials which followed the speaker's address, the following resolutions were unanimously and enthusiastically passed:—

RESOLVED: That the Executive be requested to prepare and submit to the Government of Nova Scotia at its next session of the Legislature such draft legislation as it may deem desirable for the establishment in each town, city and municipality in the Province of a fire prevention board fully empowered to make and enforce its regulations.

RESOLVED: That this convention desires most urgently to impress upon the municipalities of Nova Scotia the vital importance of ultimately using only standard hose couplings and hydrant fittings, and as a preliminary step toward standardization, the use of standard coupling adapters.

The consideration of this important subject was brought about through the influence of Alderman Reginald V. Harris of Halifax, Nova Scotia, one of the ablest young men in public life in the Province. Immediately upon his return to Halifax, Alderman Harris inaugurated a movement for the preparation and adoption of a building code for his city. The committee for this work is already appointed and the secretary of the Nova Scotia Board of Fire Underwriters has been asked to serve upon it. The committee has been furnished with copies of model building codes, and building laws suitable for all the cities in Nova Scotia to follow as a model will undoubtedly be enacted.

* * * * *

An agreeable echo of last year's campaign carried on by our friends the Credit Men is the interest being shown in fire prevention by Mr. Lee M. Hutchins of Grand Rapids, Mich., former Vice President of the National Association of Credit Men. Mr. Hutchins recently appeared before a Grand Rapids convention made up of retail merchants, the audience numbering about eighteen hundred, and delivered an interesting address upon the fire waste. He is interested enough in our cause to continue this good work, and will deliver a number of addresses in his state during the coming season. Mr. Hutchins is an attractive speaker and is, of course, an associate member of our association.

Mr. John P. Hubble, of Louisville, chairman of our committee on State Fire Prevention Associations, addressed the National Association of Box Manufacturers at their convention in Detroit in September. Mr. Hubble is a persuasive speaker and so marshaled his facts as to make a profound impression upon the convention. A lively discussion followed his address, in which other members of our association who were present took part.

* * * * *

Activity in fire prevention work has received new emphasis in the issuance of a new handbook on Fire Prevention and Protection as Applied to Building Construction, by our member Mr. Joseph K. Freitag of Boston. The work is admirably conceived and carefully and painstakingly compiled.

At the same time another member, Mr. George Velten Steeb, has brought out a second edition of his Agents' and Inspectors' Pocket Book on Fire Protection; first published in 1896.

Beside these two admirable and useful publications which any inspector must find exceedingly valuable for reference and instruction, the revision of another well-known handbook is under consideration. We refer to the Crosby-Fiske Handbook of Fire Prevention, which has already gone through four editions and which is to be reprinted shortly. With books like these on one's table, replete with useful information, there should not be much opportunity for a fire prevention engineer to go very far wrong on any essential features of his work.

* * * * *

J. Albert Robinson, Superintendent of Fire Records of the association, appeared as a speaker at the Eighth International Congress of Applied Chemistry at Columbia University, New York City, in September. Mr. Robinson's paper presented the relationships between the chemical industry and the annual fire loss of the country, frankly asking chemists what they are doing to prevent this waste, a portion of which is unquestionably due to the careless handling of chemicals. The paper set forth that the most hazardous establishments related to chemistry are those manufacturing lampblack, in which our association has the record of one fire to every five plants in the country, glass works having a fire to every eight and bluing factories one to every ten. Starch factories and tanneries have high percentage losses, each fire destroying about three quarters of a plant, but there are so many of these risks that the percentage of fires is but one to every twenty-five or thirty.

Mr. Robinson's paper was very well received and will appear in the printed proceedings of the Congress.

* * * * *

Our active member the Wisconsin State Fire Prevention Association has succeeded in arousing the interest of the members of the South Side Woman's Club, one of the leading women's organizations in Milwaukee,

in the work of fire prevention. The club members will take up inspection work, paying particular attention to the department stores, factories and other places where female labor is employed, and it is expected that excellent results will be accomplished. The fire prevention association will furnish speakers who will aid the women at any gatherings which may be held.

* * * * *

Our Springfield, Illinois, member, Honorable C. J. Doyle, formerly fire marshal but now Secretary of State, acted as toastmaster at the banquet of the Chicago and Illinois Fire Insurance Agents in September. Mr. Doyle is a popular speaker and his words never fail to carry conviction.

* * * * *

Secretary Wentworth spoke on fire prevention at the annual convention of the National Association of Mutual Insurance Companies at Buffalo, September 11th.

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Our Kansas member Mr. Chas. E. Eldridge has been active in securing the co-operation of the Kansas fire chiefs in fire prevention work. Mr. Eldridge addressed the State Firemen's Association on August 28th at Clay Center, Kan., and has been invited by a representative of the Legislature to be present at an executive meeting of this Association to consider the drafting of a state fire marshal law.

* * * * *

A glance at the program of the convention of our active member, The International Association of Fire Engineers, shows a considerable list of our members as contributors to the discussions, a number presenting original papers. These members were A. M. Schoen of Atlanta, Chief John Kenlon of New York, F. A. Raymond of New York, Geo. W. Booth of New York and Chief Howard L. Stanton of Norwich.

* * * * *

Secretary Wentworth received a warm welcome at the Annual Convention of our active member The Canadian Manufacturers' Association at Chateau Laurier, Ottawa, Ontario, September 25th. Secretary Wentworth was the speaker at a special evening meeting held in the House of Commons. At the following morning session the Convention unanimously passed the following resolution:—

> The Association in expressing its cordial thanks to the Secretary of the National Fire Protection Association, for his eloquent and effective address on the subject of "Fire Prevention," desires to record its hearty approval of all efforts that aim at the suppression of the country's fire waste. We commend the adoption of improved

building and inspection laws, the installation of private fire fighting appliances, and urge the various Provincial Legislatures to pass measures looking to the proper notification, registration and investigation of fires by Fire Marshals.

This Convention has learned with satisfaction of the election of the Manager of its Insurance Department to membership on the Executive Committee of the National Fire Protection Association, and charges the incoming Insurance Committee with the responsibility of developing plans for the furtherance of legislation in the direction herein indicated.

The above action by this important Canadian Association, following action of the Nova Scotia Municipalities above recorded, indicates a cordial support of our efforts in the Dominion. Our new Canadian Committee is planning an active campaign among the commercial bodies of Canada during the winter.

"Surely, I admit it's an old, old house, but anyway it's fireproof!"

The Automatic Control of Fire.

By Fitzhugh Taylor (Member N. F. P. A.)*

(Courtesy of *The Armour Engineer.*)

The problems which confront the fire protection engineer in the practice of his profession may be classified into two general groups, more or less allied in certain individual instances, and yet as a rule quite distinct one from the other. The first comprises those relative to prevention of fire, and involves observance of proper methods of construction of buildings, avoidance or removal of unnecessary fire hazards and intelligent segregation and safeguarding of hazards which are necessary to the conduct of certain industries or inseparable from them. The second includes problems bearing upon control and extinction of fires, and covers design, installation and maintenance of apparatus and equipment employed to extinguish fire or oppose its progress.

In dealing with problems of the second group it is in certain instances possible to provide only manually-operated protective equipment to be handled during fires by employees of property owners, municipal firemen, or both, but in many cases it is now practicable to take such measures as will furnish a reasonable degree of assurance that fires which may occur will be compelled to announce their own advent and set in motion the means for their own restraint or annihilation. This requires automatic devices fabricated, installed and finally supervised by human beings, and therefore somewhat less certain to function properly when called upon than is the hand of nature, which produces fires from the requisite combinations of circumstances. But the difficulties encountered in controlling the average fire with manually-operated apparatus, even though the latter may be more powerful because capable of a greater degree of concentration than any automatic equipment which it is commercially practicable to install, increase rapidly during the early stages of the fire development, multiplying in much more than direct relation to the age of the fire; and on the whole the automatic equipments, if perfected so far as has been proven feasible at the present time, are vastly more effective than manual apparatus in preventing heavy fire losses, even though failure to control may result in occasional individual instances from any one of the several causes which may interfere with operation of an automatic system. Their superiority lies in their ability to attack each fire in its incipiency, during the period

*Professor of Fire Protection Engineering, Armour Institute of Technology.

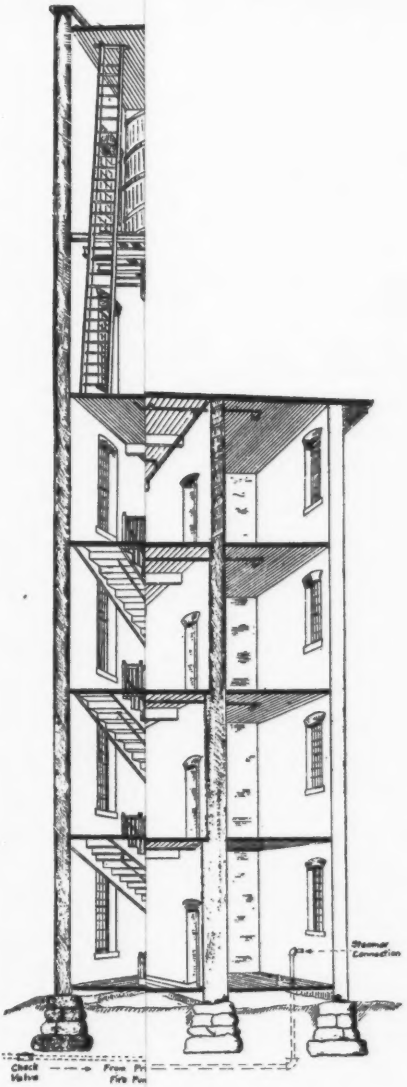
which otherwise would in most instances be consumed in discovering, locating and announcing the fire, and in transporting and placing the apparatus necessary for its control.

The most effective agent at present available for the automatic control of fire is commonly known as the automatic sprinkler equipment, and it is the purpose of the present paper to describe in a general way certain representative forms of apparatus employed in these equipments.

A sectional view in perspective, Fig. 1, bound herewith as a folder, shows a typical factory or warehouse in which is installed an automatic sprinkler equipment, and is adapted with a few alterations and additions from a diagram published by the Factory Insurance Association of Hartford, Conn. The equipment consists of one or more vertical feed pipes called risers, connected near each ceiling to horizontal feed pipes known as cross mains, the latter feeding branches equipped with automatic sprinklers and placed within a few inches of each ceiling. In the view referred to the riser is shown near the left row of columns, the cross mains are supported immediately below the girders at each ceiling, running at right angles with the girders, and the sprinkler laterals or branches are run parallel to the girders in the center of each ceiling bay. The sprinklers are essentially nozzles made of composition metal, normally held pressure tight by parts retained by an especially-compounded, low-fusing solder which melts and releases the parts under the influence of undue heat, and permits the sprinklers to distribute water over areas restricted by a deflector or distributor mounted over each orifice. These devices will be illustrated and described later in greater detail.

The riser is served by an underground feed pipe to which at least two reliable independent water supplies should be connected. Fig. 1 shows a wooden tank, usually termed a gravity tank, elevated in a tower above the highest sprinklers as one of the water supplies. It also shows an underground pipe leading from a private stationary fire pump. At the right of the view is shown a third supply pipe not infrequently used in cities which have public fire departments, known as the steamer connection. It is carried through the building wall above the ground and on a side abutting upon a street, is fitted with hose connections, and is utilized by the fire department by coupling to it a line of fire hose from the first or second steam fire engine which arrives in response to an alarm. The room immediately below the gravity tank in the tower or elevated tank house frequently contains one or more cylindrical steel pressure tanks of from three thousand to five thousand gallons capacity, connected to the tank feed pipe and normally kept two-thirds full of water, air being maintained at from seventy-five to ninety pounds pressure in the space above the water. A fifth type of supply which is sometimes chosen by the designing engineer is a connection of liberal size to an adjacent city water main, provided that the pressure normally maintained on the main is adequate for sprinkler service.

Each of the independent water supplies is connected to the underground pipe or riser through a separate swing check valve, as well as through a gate valve which is normally strapped and padlocked in wide open


Steamer Connection
Check Valve
From Fire Pump

Check
Valve

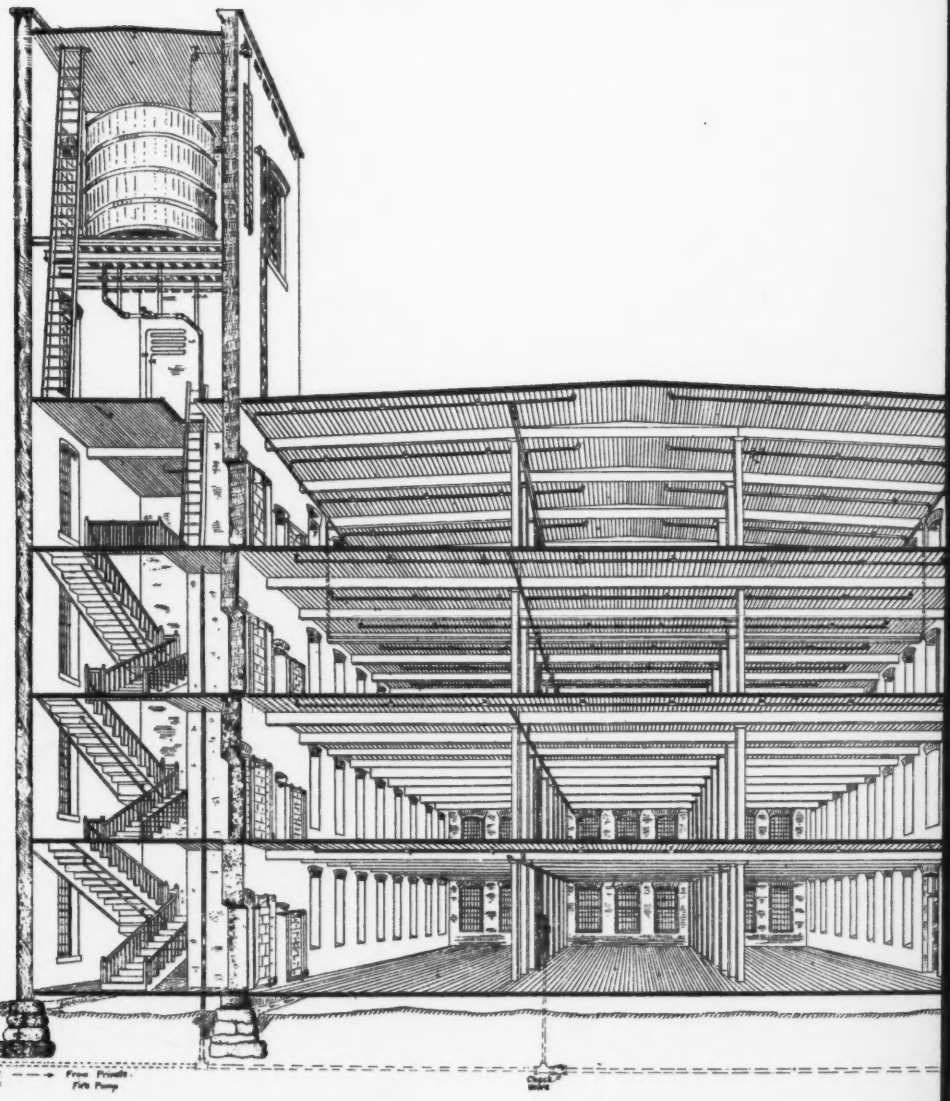


Fig. 1. Typical factory building, showing installation of automatic sprinkler equipment.

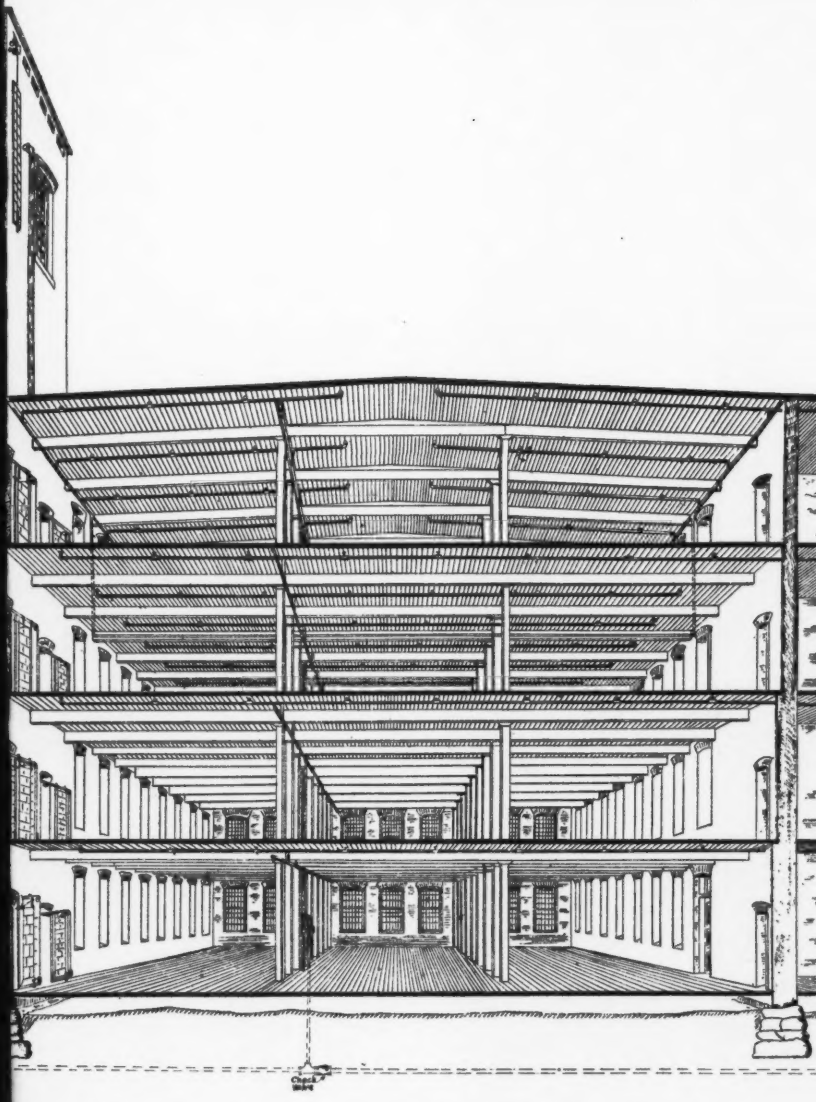
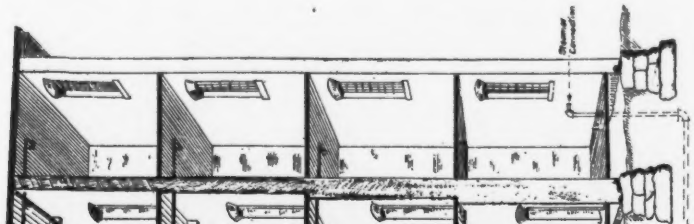


Fig. 1. Typical factory building, showing installation of automatic sprinkler equipment.



position. This arrangement of check valves permits the riser pressure to be determined always by the water supply which furnishes the highest pressure. Where pressure tanks are installed in towers or elevated tank houses they usually impress upon the riser a pressure higher than that of any other water supplies, but are prevented from delivering water into the gravity tanks or other supply connections by the check valves placed in those connections. In case of fire the sprinklers which open are then at first supplied by the pressure tanks. As the latter discharge their contents the tank pressure is reduced by the expansion of the air which is expelling the water, and when this reduction has progressed sufficiently, the gravity tank or city service checks open and permit these supplies to aid in serving the sprinklers. Meantime, if the private fire pump is placed in operation, or if a steamer couples to the steamer connection, it is probable that the pump will furnish water under a pressure sufficient to close all of the tank and other checks, and the sprinklers will thereafter be served by the pump supply so long as it is available.

The tanks used for sprinkler water supplies demand no especially detailed description in an article of this character, although the engineer who supervises the installation of a sprinkler equipment must ascertain that due care has been exercised in their design, in the selection of materials used in their construction, in the location and support of the tanks at the time of erection, in the installation of water level indicators, tank connections, ladders for inspection and heaters to maintain the temperature of the liquid contents above the freezing point in cold weather, and in provision of all practicable safeguards against deterioration.

Private fire pumps, on the contrary, are especially designed for fire service and differ in some respects from pumps commonly used for other purposes. The type of pump most widely used at present for private fire service, and preferred by most fire protection engineers for locations where its use is practicable is known as the National Standard Steam Fire Pump, and is illustrated in Fig. 2. Pumps of this type are built by several pump manufacturers, and employ no unusual principles of operation, their distinctive characteristics being mainly details of design.

The standard fire pump may be described as a duplex, double-acting, inside-plunger pump, with steam slide valves operated mechanically from the piston rods through rock shafts and rocker arms. The steam admission and exhaust passages are exceptionally liberal in area, as are the aggregate suction and discharge valve areas in the water end. The pumps are built in four sizes for discharge capacities of 500, 750, 1,000 and 1,500 gallons per minute respectively, at speeds of 120 to 140 strokes per minute, or, as commonly expressed, sixty to seventy revolutions per minute, although the designs employ no crank shafts or other revolving parts. The steam cylinders are of cast iron, enclosing cast iron pistons fitted with cast iron rings, and are equipped with manually-operated cushion valves for regulating the length of stroke and amount of steam cushion at each end of the cylinders. Two of these valves appear in the illustration, immediately below the steam chest. Each controls a small steam passage between the

steam clearance space and the exhaust passage, thus affording a means of regulating the compression in the clearance space after closure of the exhaust port by the slide valve. The slide valve rods are of Tobin bronze, and this material and the positive rock shaft drive are employed as a safeguard against stiffness of action after considerable periods of idleness. The rock shafts turn in bronze bushings for a similar purpose.

In the water end bronze water plungers without packing are usually employed, although in localities where the water contains much abrasive

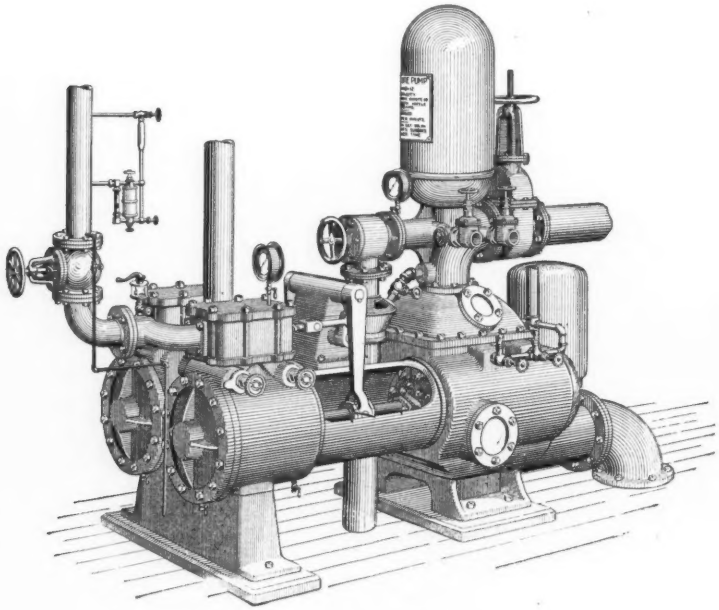


Fig. 2. National Standard Steam Fire Pump.

material, as is true of water from the Ohio, Mississippi and Missouri rivers, packed pistons running in bronze bushings are sometimes used. The piston rods are of Tobin bronze. Here again the aim is to so construct the pump that it may stand in idleness for considerable periods and yet be in readiness to deliver its full capacity on short notice. The water valves are of bronze, with rubber discs, and are of the poppet type, lifted by impact of the water and closed by brass springs. They are grouped in multiple on the suction and delivery decks in a ratio of about three to two. The aggregate valve area is liberal in proportion to the plunger area to yield full capacity at comparatively high speeds. The water end of the pump is fitted with unusually large air chambers on the suction pipe and

delivery chamber to minimize pulsation in the discharge pipe and water hammer in the suction chamber at high speeds. Gate valves for attachment of two and one-half inch hose are also attached to the discharge chamber.

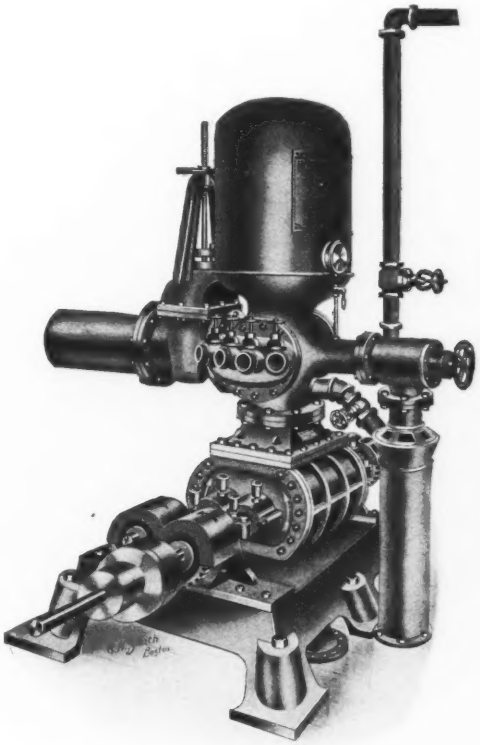


Fig. 3. Rotary Fire Pump.

The ratio of steam to water areas in standard fire pumps varies from about four to one in the smallest size to about two and three fourths to one in the largest, in order that good fire pressure may be developed by boiler pressures not exceeding fifty pounds per square inch. The entire construction is extremely rugged and heavy, to withstand on the one hand sudden admission of steam without preliminary warming of the castings, and on the other hand the shocks incident to operation under water pressures of 200 to 225 pounds per square inch, which may be obtained from these pumps where steam at from eighty to one hundred pounds pressure

is available, and which are sometimes desired at fires where water must be delivered through long lines of fire hose.

Another type of pump which has been used to a considerable extent for sprinkler supplies in water-power mills is that known as the rotary or gear pump. A pump of this type, especially designed and fitted for fire service, is illustrated in Fig. 3. Its principle of operation is the same as that of the small gear pumps now quite widely used for circulation of cooling water through the cylinder jackets of internal-combustion engines, and involves the use of two parallel shafts geared together and moving in opposite directions, each carrying within the casing a large cam or pinion, these meshing one with the other, trapping water between the gear teeth and the wall of the casing, and delivering it upward into the discharge chamber. Fig. 4 is a sectional diagram of a pump of this type. Rotary

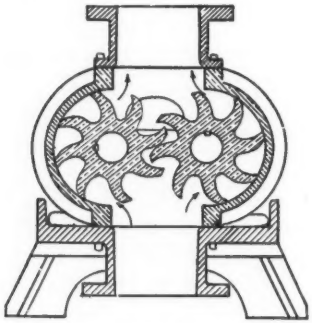


Fig. 4. Section of Rotary Fire Pump.

pumps have been utilized for fire service mainly in properties equipped with water power and lacking steam plants suitable for driving steam fire pumps. They can be readily driven by water wheels or from countershafts, and have been reasonably successful in these locations.

The tendency of urban property owners to adopt central station electric power has created during recent years an active demand for fire pumps suitable for electric driving without speed reduction, and centrifugal pumps of the multistage patterns are now being perfected for this service. It is in certain instances possible to secure a fairly reliable pump supply for a sprinkler equipment by utilizing an electrically-driven centrifugal pump where the available power facilities would not permit the use of a pump of the positive-displacement type, but pumps of the latter class are more flexible in their performance, and are therefore preferred where it is found practicable to make use of them.

Perhaps the simplest imaginable expedient for compelling a system of piping, normally under water pressure and arranged as has been illustrated and described, to discharge water automatically upon any fire which might subject it to abnormal temperatures, would be to perforate the piping

and fill the perforations with some fusible material, such as solder, which when cold would have sufficient strength to resist the water pressure and remain tightly in the openings in the pipe. But fusible plugs of such a nature would necessarily be directly in contact with the liquid contents of the piping, and under the influence of fire could be heated very little if any more rapidly than the water and the piping. The resulting delay in delivery of water would in many instances be fatal to control of the fire, and to minimize this delay the outlets of sprinkler piping are equipped with devices which will release the water when an abnormal rise of temperature occurs, but which are designed in such a way as to remove the fusible elements from the cooling influences of the water and piping.

Automatic sprinklers, or sprinkler heads as they are colloquially termed, are of various forms, but usually of one of two general types. Fig. 5 is a sectional view of one of these, and sprinklers of this general

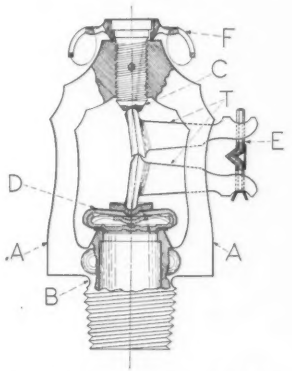


Fig. 5. Sectional view of sprinkler head.

type, differing considerably however in design, are now manufactured and installed by several sprinkler equipment companies. The body, B, of this sprinkler is a casting of composition metal. The lower end carries a one half inch pipe thread, and is cylindrically bored to form a vertical nozzle. Extending upward from diametrically opposite points on this vertical tube are two arms, AA, which join overhead and are drilled and tapped at the junction to receive a vertical retaining and adjusting screw, C. The nozzle orifice is normally closed by a disc or cap, D, composed of several pieces of metal so formed and joined as to exhibit elasticity to a marked degree. The cap is held upon the nozzle by a pair of toggle levers, T, which are forced downward upon the cap by the adjusting screw in the top of the frame, and whose outer ends are held together by a fusible link, E, consisting of two or more plates of composition metal soldered together with a specially compounded solder. A distributor or deflector, F, is secured to the top of the frame by the adjusting screw.

The drawing shows that the bearing of the toggle levers upon each other does not lie in the center line which passes through their bearings upon the cap and the adjusting screw. When the latter is set downward, therefore, to press the toggle system against the cap, the soldered link is stressed in tension by the tendency of the toggle levers to separate at that point. The vertical arms of the frame are also stressed by the reaction from the adjusting screw, and this stress, as well as that in the link, is present in every sprinkler of this type as it stands in service. The effect of fire upon the head is the fusing of the solder in the link, whereupon the stresses resident in the frame will usually scatter the toggle levers and parts of the link for a distance of several feet, permitting the cap to be blown from the nozzle by the water pressure. The jet which issues from the

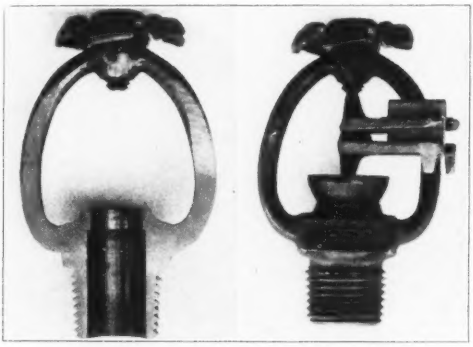


Fig. 6. Fig. 7.

nozzle strikes the upper portion of the frame and the deflector, and is thereby broken up and distributed.

Fig. 7 shows a sprinkler of the type just described, differing in details of design from that of Fig. 5. Fig. 6 shows the same head with the working parts removed, and the lower portion of the frame sawed in section to show the form of the nozzle waterway.

Another sprinkler which is widely used is illustrated in Figs. 8 and 9. One view is a section. The body, B, screws into the tee in the line pipe: the yoke or frame, A, screws into the body and carries the deflector, J. Between A and B is held a flexible metal diaphragm, C, with a half-inch hole in the center. Into this hole fits the hemispherical glass valve, E, held in position by a small metal cap and a strut of three pieces, F, G and H. These three parts are held together by soft solder fusing at about 166 degrees Fahrenheit.

When the temperature of the solder reaches this point, the disruption of the strut begins, and ultimately takes the form of a rocking motion one part about the other. During this movement the flexible diaphragm with

the water pressure under its entire area holds tightly against the glass valve until as the strut finally falls apart both valve and strut are thrown out into the room; then a stream of water, striking the deflector, is scattered in all directions.

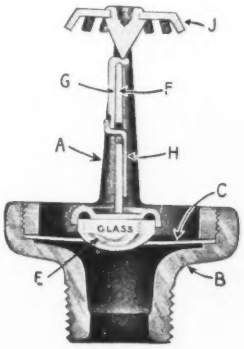


Fig. 8.

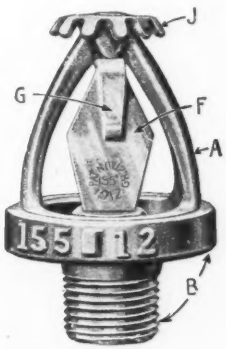


Fig. 9.

The solders most commonly used in the manufacture of sprinklers have fusing temperatures of about 165 degrees Fahrenheit, and these sprinklers are known as standard degree heads and are used for all ordinary locations.

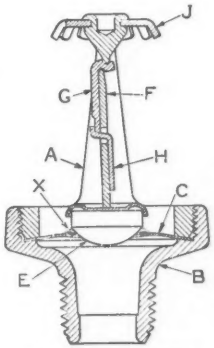
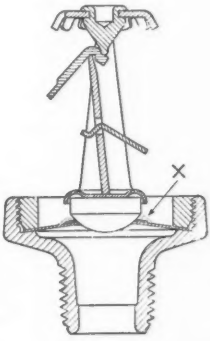


Fig. 8. (a) on center.



(b) Off center (starting to operate).

Certain locations, such as boiler rooms, dry rooms and spaces under skylights, which are frequently warmed by rise of warm air from below and by the direct rays of the sun from above, demand heads made with less sensitive solders, and several grades of harder solder are regularly used for the purpose.

While a standard degree sprinkler, when slowly heated in water or oil, will usually fuse when the temperature of the submerging liquid reaches approximately 165 degrees, it must not be supposed that in the average fire the heads will fuse immediately upon the attainment of that temperature by the surrounding air, because the specific heat of air is much less than that of the liquids mentioned, and air is correspondingly slower in conveying to the soldered links the quantity of heat necessary to raise their temperature to the fusing point.

Several methods may be used to demonstrate the sensitiveness of an automatic sprinkler. For example, a standard degree sprinkler of the type shown in Fig. 5 may be held in one hand and a parlor match in the other. If the match be ignited, and held at such an angle as to produce the maximum duration of flame and keep the soldered link continuously enveloped in the flame, the sprinkler may possibly open before the flame ceases, but usually, unless the experimenter has acquired some skill by practice, a second match is required to fuse the link. In this simple test the link is plunged into a small flame whose temperature is perhaps 2,000 degrees Fahrenheit, and is apparently slow to operate. On the other hand, a similar sprinkler dipped bodily into a kettle of water or oil whose temperature is 175 degrees Fahrenheit will open in from five to ten seconds. If one or two liberal armfuls of dry excelsior be piled and ignited on the floor of a room equipped with sprinklers, it is probable that within a few seconds the flame will reach a sprinkler overhead, and a standard degree head enveloped in a flame of such a volume may readily open in from ten to twenty seconds after the first flame contact. In contrast to this action, a test fire built of comparatively coarse material with only sufficient kindling to insure its ultimate growth will gain headway slowly without discharging large quantities of flaming volatile matter, and may burn for several minutes before fusing the link of a sprinkler directly overhead.

The rate at which an automatic sprinkler discharges water after being opened by fusing of the solder is obviously dependent upon the water pressure to which it is subjected. Fig. 10 displays a curve which represents the relation between water pressure and rates of delivery obtained experimentally from a sprinkler of the pattern illustrated in Fig. 8, and this curve is fairly representative of the performance of most modern automatic sprinklers. Sprinklers may very fairly be considered effective as fire extinguishing agents when discharging water under a pressure of fifteen pounds per square inch at the nozzles, if spaced over the ceiling in accordance with standard practice, but somewhat higher pressures are preferred and are available in a majority of sprinklered buildings. Many fires have doubtless been controlled or extinguished by sprinklers on upper floors of buildings served only by gravity tanks, where the available pressures were considerably less than that quoted.

Fig. 11 illustrates an automatic sprinkler in operation, the view showing the device mounted upon a test stand especially arranged for study of the water distribution and provided with reference circles ten feet in

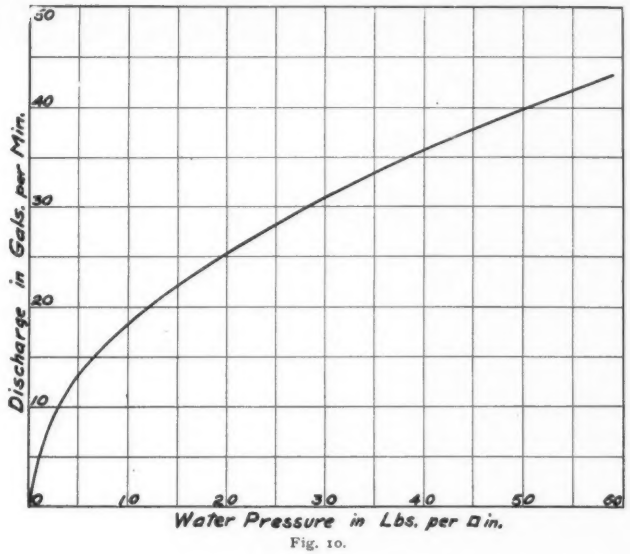


Fig. 10.

diameter, mounted on vertical rods as aids to the observer in judging the floor and ceiling areas covered. Most sprinklers yield a somewhat more scattered distribution with a lower central density than that illustrated, which is shown discharging at a pressure of about forty pounds per square inch.

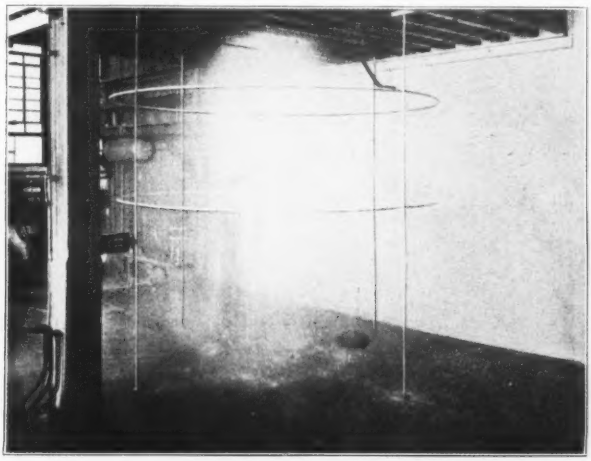


Fig. 11.

The effectiveness or protective value of an automatic sprinkler equipment is dependent to a very considerable degree upon the location of the sprinklers with respect to each other and to the ceilings. In order to be effective as fire extinguishing devices, sprinklers must be capable of opening promptly in the presence of fire, and of wetting adequately the ceiling and floor areas allotted to them by the designer.

In designing a sprinkler equipment care is first taken to devise an arrangement which will be favorable to prompt opening of the heads in case of fire. To attain this end all practicable expedients are employed to compel the products of combustion to bank or accumulate at the ceiling directly over their source. Ceilings such as those shown in Fig. 1 promote promptness of sprinkler operation because the girders divide them into channels or bays, any of which may act to retain a thick stratum of hot gases from a fire under it, a condition favorable to operation of sprinklers in that bay. Hot gases may fill one bay and underflow the girders, thus attempting distribution over the ceiling transversely to the girders; but each successive bay as it is entered by the gases tends to retard their further progress until it is filled, with the result that the gases are to a considerable extent retained by the ceiling directly over their point of origin, which is the point demanding sprinkler service. Windows which extend to the ceiling line, and open elevator and stair wells and hatches are causes for apprehension, because they afford the hot gases means of escape from the ceiling localities where it is desirable that the gases should be retained. When sprinklers are to be installed in buildings whose ceilings afford escape openings of the character mentioned, it is wise to build aprons or curtains around the openings if the latter cannot be entirely enclosed, to aid the floor beams in retaining hot gases. Obviously, scant clearance between ceilings and sprinklers makes for promptness of operation, and the heads are therefore mounted as close to the ceiling as is permitted by the character of the ceiling and the requirement of good water distribution.

After adequate provision has been made for banking of heat around sprinkler laterals, the designer must decide upon distribution and arrangement of the heads. It is common practice to assign from eighty to one hundred square feet of floor or ceiling area to each sprinkler. The best arrangement is that shown in Fig. 1, where at least one lateral is installed in each bay, lying parallel to the girders; but the cost of this arrangement is prohibitive for joisted ceilings having joist channels only one or two feet in width, and in such cases the laterals must run transversely to the joists. Care must then be observed in location of the heads on the various laterals, for unless every joist channel can receive water from one or another of the laterals it is possible for fire to travel unchecked along channels which are not so protected.

Buildings whose occupancy is such as to require that they be heated during all seasons are equipped with what are known as wet-pipe sprinkler systems, the distributing piping being maintained under full water pressure at all times. In buildings such as warehouses, which are not well heated during cold weather, such systems would suffer from freezing of the con-

tained water, and buildings of this class are therefore equipped with dry-pipe systems. The arrangement of sprinklers and piping is very similar in the two types of system, although in piping a dry system the pipes are not infrequently pitched toward the riser to a slightly greater degree than in wet systems to facilitate drainage, and the sprinklers are invariably installed in the upright position to avoid retention of water in their nozzles, a practice which is sometimes departed from in installation of wet systems, although it is preferred for the reason that most sprinklers yield a some what better water distribution in the upright position than when pendant.

The dry system differs from the wet principally in that at the base of the riser is installed an automatic valve which is subjected upon its lower side to water pressure from the underground supply pipe, and on its upper side to a considerably lower air pressure which is normally maintained throughout the distributing system of pipes. These valves are known as dry-pipe valves, and possess differential properties by virtue of which they may be held closed against the water pressure by a considerably lower air pressure in the riser, and are so constructed as to open automatically and admit water to the risers, which they control when the compressed air is released from the sprinkler piping by opening of one or more heads. Most buildings have at least one or two rooms which are heated in cold weather, and in which dry-pipe valves may be installed without danger of freezing of the water in the supply pipe; in buildings which are unheated throughout, small wooden closets or brick vaults are built around the dry-pipe valves, and in cold weather a lantern or small heater in each enclosure prevents freezing within the supply pipe.

Sprinklers on wet systems deliver water more promptly after fusing than on dry systems, the air contents of systems of the latter type requiring an appreciably longer time for expulsion before water reaches the open heads. For this reason wet systems are selected for all locations where danger of freezing is not present, and in some localities it is accepted practice to maintain dry systems only during the cold seasons, these equipments being maintained as wet-pipe systems during the remaining months of the year.

Dry-pipe valves may readily be fitted with attachments which will cause fire alarms to be sounded automatically by the action of the valve mechanism at the time of opening, either by actuating an electric circuit-closer or circuit opener, or by admitting water to a small Pelton wheel which may drive the tapper of a gong. These valve attachments are at the present time fairly reliable as means of producing automatic fire alarms, providing the signaling apparatus is maintained in operative condition. Automatic alarm valves are also made for installation in risers of wet-pipe systems, generally utilizing the action of a specially-designed swing check valve to actuate the fire alarm apparatus. They are widely used, and are fairly successful under favorable conditions, but they are less reliable than most of the other apparatus employed in sprinkler equipments at the present time.

Automatic sprinkler equipments, contrary to a common understanding

of their functions, are not relied upon primarily by the fire protection engineer to carry the entire burden of extinction of fire. Many fires, especially those resulting from the phenomena popularly grouped under the classification of spontaneous ignition, originate at points which are not readily reached by the discharge of sprinklers, although every effort is made by the designing engineer to limit these inaccessible places as far as is possible. Some fires, such for instance as those which are caused by slow heating within a pile of neglected rubbish, demand for their complete extinction that the pile of fuel be forcibly scattered and deluged by a powerful stream, and sprinklers are obviously incapable of furnishing service of this character. The task allotted to the sprinkler equipment in every such instance is to discover the location of the fire, signal for aid through the medium of the fire alarm attachment previously mentioned, and by distributing water over and around the fire hold the latter in restraint until assistance arrives. If the equipment successfully fulfills these of its obligations it is entitled to full credit. Very frequently, however, fires are completely extinguished by sprinkler equipments within a few minutes of their origin.

The fire record of automatic sprinkler equipments is a remarkably creditable one. For a number of years the National Fire Protection Association has compiled and published tabulations based upon reports by its members and others covering fires in sprinklered buildings throughout the country. The reports cover equipments known to be faulty in arrangement or character of apparatus, as well as those considered worthy of thorough confidence, and include records of fires in many classes of property; and not long ago, when the total number of fires reported exceeded 6,000, the failures to control by sprinklers aggregated only between six and seven per cent of the total reported fires which had been successfully controlled by sprinkler equipments. Of the ninety-three per cent reported as successful about one third called for the service of only one sprinkler each, and more than one half involved three sprinklers or less. Careful analysis of the six per cent of failures shows that a large proportion of this number yielded explanatory evidence of the causes of the failures, such for instance as closed gate valves in the water supply pipes or recognized defects in the equipments, and the obvious deduction from such an analysis is that there are very few fires which cannot be held within bounds by correctly designed and properly maintained automatic sprinkler equipment.

Precautions Against Freezing of Fire Apparatus.

The season is now at hand when fire apparatus and water pipes generally are *liable to freeze*, and a very small freeze-up may temporarily disable a large part or the whole of a sprinkler equipment. Discover any defects that may exist now. A sprinkler system requires special care and attention in winter.

Instruct the person having charge of your fire appliances:

1. To ascertain if all portions of buildings are properly heated at all times to prevent freezing in any of the sprinkler pipes, particular attention being given to exposed places, such as hallways, entries, stair towers, under sidewalks, show windows, shipping rooms, attics, roof monitors and skylights.
2. To examine tanks and all pipes, fittings and valves, whether for steam heating, general water service, or fire protection. *See that none are frozen* or have been frozen, and that they are *all in operative condition*, and where there is any liability of freezing, arrange the necessary protection. All metal work supporting tanks should be thoroughly cleaned from rust and painted, also tank hoops.
3. To examine carefully and provide suitable boxing around any pipe lines which may be in an exposed location (either between ground and first floor, between buildings, or near windows, doors, etc.). Make frequent tests during the winter of such sprinkler systems in order to make sure the piping is not frozen.
4. To ascertain if sprinkler dry valves are in working order, not leaking, and piping thoroughly drained; if alarm connection and gong are in order; if air pumps can be depended on for the winter.

NOTE.—Do not overlook low points on dry system not controlled by main drain. Blow low points out occasionally to free from condensation.

5. To see that *all valves are open that should be* open, and try water outlets to ascertain if all pipes are free and ready for service.
6. To see that *extra sprinklers* are on hand in case of need to replace frozen or melted heads.
7. To be sure that your engineer is fully posted as to the purpose and intention of every valve and pipe.
8. To try your pumps and see that they are in proper working order.
9. To test all of the *hydrants* and *indicator posts*, and see that they *drain properly*.
10. To *instruct the night watchman* thoroughly in the use of all fire apparatus and the operation of all valves.
11. To examine the end of suction pipe to see that leaves or other refuse matter have not clogged up the holes in the strainer. The capacity of the pump may be greatly reduced by this defect.
12. To take measures to prevent freezing of water in casks and pails in cold buildings, at the same time avoiding danger of water damage.
13. To empty and recharge chemical extinguishers to insure their being in perfect working order.

A thorough examination should be made of the entire heating system before putting it into service. All heating pipes should be carefully brushed down, and, where the piping is located along walls, any rubbish or litter which may have accumulated should be removed and pipes kept free from dangerous contact with walls, partitions, etc.

When it becomes necessary to close a sprinkler valve during working hours, a competent man should be stationed at the valve, so that the water can be turned on immediately in case a fire occurs.

When necessary to make changes in sprinkler system, extra care should be taken to have the least possible portion of the equipment out of commission at one time.

Whenever it is necessary to shut water off sprinklers, or in any way modify the fire protection, the inspection department having jurisdiction should be first notified.

The Fire-bug and the East Wind.

By E. T. Allen (Member N. F. P. A.).*

Forester Western Forestry and Conservation Association.

"No, I'll not burn my slash this spring,"
The moss-back logger said,
"I'll trust to God and luck again;
Expense is what I dread."

"It's time to hit the trail again,"
The careless camper said,
And left his little fire ablaze
Within its leafy bed.

"I'll light another cigarette,"
The idle loafer said,
And chucked his old snipe in the brush,
One end still glowing red.

"Let's punch the screen out of the stack,"
The donkey fireman said.
And so he did and all the sparks
Sailed blithely overhead.

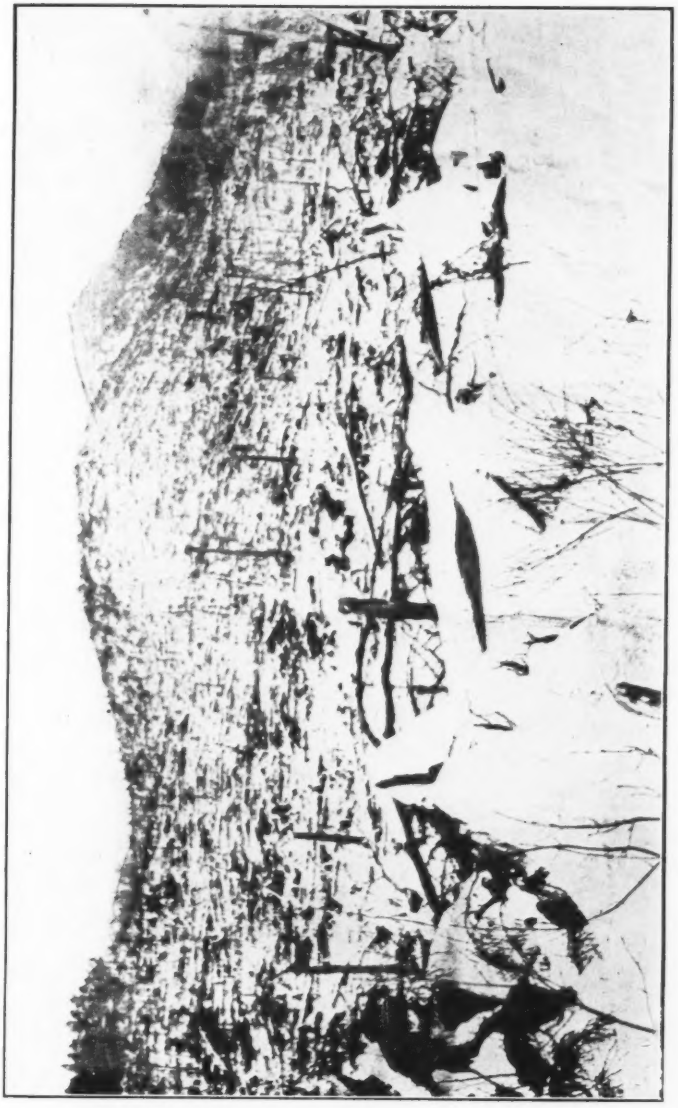
"Come on, we'll dump our ashes now,"
The railroad trainmen said.
The train soon fanned them far and wide
As on its way it sped.

"I think I'll blow an hour or two,"
The restless East wind said,
Then liked it so he changed his mind
And blew a week instead.

"Millions in lives and timber lost,"
The newspapers next said.
What made those fires all start at once?
We wondered as we read.

"It wasn't us, it was that wind,"
The fools in chorus said.
So they're alive and loose this year—
We hope the *wind* is dead!

* Member Committee on Forest, Brush and Grass Fires, National Fire Protection Association.



Burnt over area in the Adirondacks, U. S. A.

Slope on which seven fires have occurred. This is now practically a desert.

Forest Fire Waste in Canada.

By Percy Robertson (Member N. F. P. A.).

Chairman Committee on Forest, Brush and Grass Fires

The loss of timber and equally serious indirect damages caused by our forest fires has been, and continues to be, enormous.

The Dominion forestry officials in their last report estimate that more than one half of the original timber supply has already been destroyed by fire; that government stumpage dues at the moderate rate of fifty cents per thousand feet on the timber destroyed would have yielded a revenue of $1,000,000,000; and that for every foot of timber ever cut in Canada, seven have been destroyed by fire. This destruction continues, and a reliable authority estimates that the direct loss by forest fires during 1911 exceeded the losses by fire from all other causes,—and the former was almost entirely uninsured. Surely such a state of affairs demands the prompt adoption of vigorous and intelligent preventive measures.

It will be seen from the estimates given above that the present annual cut (about $60,000,000) is a small factor in our timber problem in comparison with the loss by fire; although the responsibility for the present inflammable condition of the forests where timber has been cut, and for the extent of many of our recent fires, must be placed on the reckless manner in which our lumbering operations have been permitted to be carried on. Regard has been had only for economy in getting the timber to the mill and no attempt has been made to safely dispose of the slash or debris, so when fire occurs in areas which have been cut over, the ground condition facilitates the spread of the fire as well as increases the damage.

The causes to which most forest fires are attributed are lightning, sparks from locomotive and logging engines, camp fires left smouldering, fires set by settlers to clear land getting beyond control, and carelessness of prospectors, campers and settlers.

Lightning we cannot control; but with a satisfactory ground condition losses from this cause should not be serious. Fires from locomotives can be reduced in number by the adoption of safety devices in conjunction with efficient patrol and properly cleared right-of-way and would be practically eliminated by the use of oil for fuel. Fires from other causes can also be greatly reduced by an educative campaign and by enforcing precautionary regulations and proceeding against offenders.

Condition of Michigan forest through which fire has passed.

It is constantly pointed out that fire waste is a direct loss of wealth to the community, and in the case of forest fire waste the loss does not stop at the actual loss of timber and of the advantages of finally manufacturing and disposing of the products. There are serious indirect damages. For instance, where fire has passed the subsequent growth is of an inferior character and in some cases the land is rendered barren. This summer, fires in the Porcupine district consumed the entire soil in some places, leaving the rock bare. Moreover, there are hundreds of thousands of acres in Northern Ontario in this condition.

Again, the forest floor when burnt over loses much of its ability to retain moisture, and when the rain and melted snow run off they carry away a larger percentage of soil. The failure to retain moisture affects the storage of water and tends to produce freshet or flood conditions, and the soil which is carried away is deposited in watersheds and navigable streams.

Damage to water flow and by erosion is much less where the timber is merely cut, than where the ground is burned over, the trees themselves being a comparatively unimportant factor in retaining the moisture.

Forest fires are divided into three main classes; namely, Ground, Surface and Crown.

Ground fires burn in the forest floor, which is often of a peaty nature. These fires burn slowly, and while very persistent do not travel rapidly.

Surface fires feed on the shrubs and surface debris and not only cause numerous crown fires but do great damage to the forest floor and young growth.

Crown fires burn in the tops or crowns of the trees, but seldom reach large proportions except in high winds, when they travel rapidly and are the greatest factor in the spreading of fires, owing to the burning debris from them being carried with the wind and starting surface fires.

In considering the measures necessary to arrest the enormous loss through forest fires it must be borne in mind that conditions vary in the different localities and the precautions which might be effective in one district might be either unnecessary or ineffective in another. Each district must therefore be considered by itself, although all might to advantage be under one executive head, and considerable practical advancement might follow an annual gathering of representatives from the various districts for the purpose of general interchange of ideas and experience.

What appears most necessary is,—

First. To enact regulations appropriate to each locality, requiring due care and precautions to be taken by those who may cause fires and for the conduct of lumbering and other operations in a manner which will not increase the inflammable nature of our forests.

Second. To establish an efficient organization. For its requirements I cannot do better than quote what the Canadian Forestry Association's Committee on Forest Fire Legislation considered the essentials; namely,—

"1. A proper head, an officer with experience and with well defined

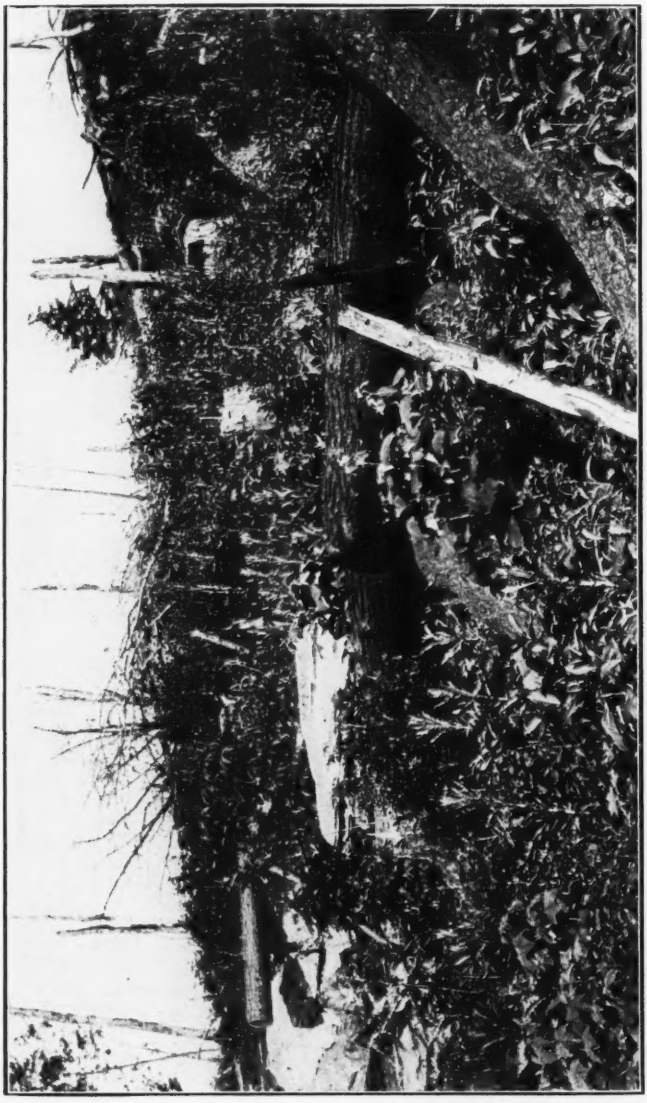


Illustration of growth following forest fire. Logging was proceeding in this area when fire occurred.

powers and duties, but with large discretionary powers, who shall devote himself to this interest alone.

"2. A proper personnel carefully chosen—not necessarily nominated by limit holders—of permanent, paid rangers with constables' power and the right to arrest without warrant any one suspected of having contravened the law, who during the off season can work in preparing for the dangerous season. The success of the organization depends on the character of these men.

"3. Additional paid patrolmen during the dangerous season, a variable number according to needs, and obligation on every citizen to aid under penalty when called upon in extinguishing fires.

"4. Responsibility properly divided, enforced by penalties, and inspectors active in looking after the rangers, and concerned in educating the people and improving the service.

"5. Districting the country with a view of collocating similar conditions in such units as a patrolman can readily oversee or an inspector inspect, and making these officers responsible for the safety of their unit.

"6. Early discovery of an incipient fire is essential; hence there should be watch towers or lookout stations, properly distributed. Such watch towers fully equipped cost, with shelter house, between $300 and $500; one every twenty miles even would save its cost the first year by reducing the number of wardens necessary.

"7. Rapidity of getting to a fire is essential, hence building of trails to make districts accessible and connecting watch towers by telephone lines, which can be built and equipped for $25 to $50 per mile.

"8. Ample funds by special taxes to organize, equip and keep up the service and enforce the law.

"The main requirement is the head man who, if a capable organizer, would work out the detail fit for each condition, and, if left to act with authority and considerable latitude, would soon have the whole community assisting his efforts.

"Your committee believes that the country is ready for this supreme effort to get rid of the fire evil and thereby to make the beginnings of forestry,—a rational management of forest lands,—possible."

The Dominion and some of the Provinces have made more or less serious efforts to improve conditions; but there is urgent need of an effective organization, provided with sufficient funds, and above all free from the political interference which so hampers the effectiveness of government departments. Moreover, the occupation of protecting forests against fire should be placed on the plane of a profession instead of being considered, as at present, a temporary employment to be abandoned at will by the employee, and not requiring any special knowledge or application.

Fortunately for Canada the Forestry course at the University of Toronto, under the able and enthusiastic direction of Dean Fernow,* is turning out a body of men whose training makes them both able and

* Member Committee on Forest, Brush and Grass Fires, National Fire Protection Association.

Undesirable ground condition following logging operations.

anxious to assist in solving this question. Other institutions have already followed suit, and when the influence of this educated body is felt we may look for intelligent handling of this important problem.

Some very effective work has been done in the United States, both by the Government and by owners of timber limits. Several public bodies on this Continent, including Conservation Commissions and the National Fire Protection Association, have interested themselves in the problem, and the publicity given to their reports will, without doubt, be beneficial. There is urgent necessity, however, for immediate action being taken in Canada, where we are still in the experimental and discussion stage, while the danger of repetition of the fires of recent years is not materially lessened.

Carpet Factories and Carpet Yarn Mills.

By Henry Penn Burke.

Carpets may be classified as of the following kinds, and generally speaking range in this order from the cheapest to the most expensive grades: Rag, ingrain, smyrna, tapestry, tapestry velvet, axminster, body brussels, wilton.

Carpet yarns, literally speaking, are any and all yarns used in the manufacture of carpets, but in the "trade" "carpet yarns" means a particular class of yarn, which however ranges in quality from a good all-wool yarn to one of mixed stock with varying percentages of shoddy (made from old carpet or other rags), cow hair, goat hair, cotton and jute. In the following description of the yarns and processes incident to the manufacture of the various kinds of carpets, the carpet yarns mentioned in each case vary in accordance with the quality of the carpets.

The processes and hazards of the carpet yarn mill are described later in this article.

Rag Carpets. These are woven almost entirely on hand-power looms constructed largely of wood. The warp is of cotton and the filling of cotton rags cut into narrow strips about one inch wide. The rags are frequently made from old garments, but in recent years, with the revival of this industry, trimmings from new cotton goods have been used, and more recently cotton fabric or weft, woven especially for the purpose, is cut into strips for a filling in rag carpets.

The hazard in this class is very mild; the use of power being generally confined to winding of the cotton rags on light machines. The reason for the use of hand looms is that the rags do not unwind from the bobbin of the shuttle as easily as yarn and would catch and prevent the shuttle from passing freely back and forth between the warps. The general condition and care as to cleanliness are about the only features in this class.

Ingrain Carpets. This is the only kind of carpet which, in its best grades, is composed entirely of the so-called carpet yarns; in the cheaper grades, however (frequently styled "union"), as much as fifty per cent of cotton yarns is used. The looms for weaving ingrain carpets are of the "Jacquard" type, which form the pattern in the carpet by means of pattern cards or perforated pasteboard sheets sewed together with cotton twine; these pass through the head or top of the loom and regulate the operation of the heddles through which the warps pass and which produce the pattern in accordance with the perforations in the pattern cards.

The feature of the "Jacquard" loom is the loom harness or the many strands of cotton twine saturated with boiled linseed oil, which extend from the heddles through which the warps pass to the top of the loom about ten feet high; these are the cause of fires spreading with great rapidity in a room filled with this style of looms. The Jacquard loom is large and of complicated mechanism and more susceptible to water damage than any other loom except the axminster loom. Where gas lights are used at Jacquard looms, the jets should be examined as to whether they swing into direct contact with, or close enough to, the loom harness to ignite it, and where such is found to be the case, they should be made rigid or otherwise arranged to prevent the possibility of their igniting the loom harness.

Smyrna Rugs and Carpets. These are made by the chenille process; that is to say, there are two processes of weaving. The first is the weaving of a weft on ordinary looms with cotton warp and carpet yarn filling; the strands of the warp are about one-quarter inch apart, and after the weft is completed it is run through a cutter with knives on a rapidly revolving cylinder which cuts the weft between the strands of warp, forming what is called chenille, which consists of the long strands of the warp holding together short cross strands of the filling or carpet yarn.

The second weaving produces the carpet or rug, and this is done on plain power looms and not infrequently on hand looms, for much the same reason that rag carpets are woven on hand looms; the chenille, because of its thick character, does not unwind from the bobbin as freely as ordinary yarn, and it is also necessary to match the chenille filling carefully to properly form the pattern. In the second weaving the warp is of cotton while the filling consists of alternate strands of the chenille and of jute yarn.

The chenille cutter, which runs at high speed, should be enclosed to prevent the spread of fly from that source. The looms used are of plain type or without complicated mechanism except that for wide rugs the looms are of corresponding width, and for that reason only in such cases are more expensive. Finishing includes steaming and shearing.

The particular feature in this class is the chenille process, which tends to a large amount of fly and a very rapid spread of fire. Large quantities of chenille are frequently kept on hand, and this is subject to total loss from water. The chenille process, together with insufficient care as to cleanliness, make this class, from a fire hazard standpoint, the least desirable of carpet factories.

Tapestry and Tapestry Velvet Carpets. These consist of a warp of

carpet yarn printed with aniline colors on large wooden cylinders in accordance with the pattern desired; which printed warp is then subjected to live steam in large closed iron cylinders, after which it is dried. In weaving, the printed (carpet yarn) warp which forms the pattern is woven over wires, causing it to be raised in loops on the surface of the carpet, and in the making of tapestry velvet these wires are sharpened at the end in the form of a knife and as each wire is withdrawn automatically by the loom the loop is cut, leaving the strands perpendicular to the weft and forming a velvet-like nap or what is called "pile." In addition to the printed warp there is a warp of cotton yarn and a warp of jute yarn, while the filling is either of linen or jute yarn. Of the ordinary tapestry carpet there is little or no finishing to be done, but in the case of tapestry velvet carpet the surface of the carpet is steamed, sheared and brushed.

The hazards in tapestry carpet-weaving reside principally in the drying features. The aniline-color printed "carpet yarn" warps are dried in various ways, generally in board enclosed driers and the arrangements of the steam pipes in the driers should be noted. They should always be on iron supports and preferably at the sides of the drier. They are frequently at the bottom, however, and if so there is liable to be an accumulation of fly falling from the yarn on the pipes and between them. Where this arrangement exists the drier should be cleaned very frequently. A better arrangement than either of the foregoing is where the heat for drying is furnished from a fan and steam pipe coil. Oil cloth covers used on the wooden cylinders in printing the warps are also dried after washing and the foregoing remarks as to the arrangements of the drier apply here.

The jute and cotton warps used are color-sized and dried on steam-heated cylinders, and this feature presents little hazard. The jute filling yarn is frequently color-sized, but no drying of this is done, as it is woven in a damp state.

A very cheap class of tapestry carpets is woven as described above, except that the carpet yarn warp which forms the surface of the carpet is plain and after weaving is printed exactly as wall paper and dried in a large (generally wood encased) drier. The previous statements as to drying arrangements apply here. The arrangements for drying and the general condition and care as to cleanliness are the principal factors in this class.

Axminster Carpets. This make of carpet is woven on special looms with complicated mechanism, for the reason that the pile or nap of the carpet is inserted at each stroke of the loom from a series of reels on a traveling apron extending to the top of the loom and for some distance overhead at the back of the loom. Occasionally axminster carpets are woven on looms with "Jacquard" attachments, in which case the features of Jacquard looms as previously noted in connection with ingrain carpets apply. The yarn forming the pile or nap is carpet yarn dyed in aniline colors and arranged on the reels above referred to in accordance with the pattern desired. The warp is of cotton yarn and the filling is of jute yarn.

Finishing in this class includes shearing, brushing, sizing and drying of the carpets. The sizing and drying is a continuous process, the carpet

passing through the sizing machine and then continuously through a steam-heated drier, generally wood encased. The arrangement of steam pipes in the drier and the facilities for cleaning out accumulations of fly are to be noted, and this is the only particular hazard in this class. The looms used for axminster weaving being of complicated mechanism are expensive and more susceptible to damage from fire and water than any other class of carpet looms.

Body Brussels Carpets. In general appearance these resemble tapestry carpets, but are more durable because better grades of yarns are used, and they retain their colors better because the yarns forming the pattern are dyed in aniline colors instead of being printed as in tapestry carpets. This class is woven on Jacquard looms similar to those for weaving ingrain carpets, as previously described, and the yarns forming the pattern are woven over wires (thirteen to the inch in the best grades) which form loops on the surface of the carpet. Carpet yarns form the pattern and are in the form of warps which are dyed in aniline colors, and generally five to six of these warps are used as required for the pattern. Another warp is used which is of cotton or linen yarn, but in cheaper grades this last warp is of jute yarn; the filling is of linen yarn.

The hazard in this class is mild; the arrangements of gas jets at the the Jacquard looms, the general condition and care as to cleanliness being about the only features.

Wilton Carpets. These are in the same relation to body brussels as tapestry velvet are to tapestry; in other words, wilton carpets are body brussels with the loops on the surface cut, forming a pile or nap, and the only additional features as compared to body brussels are steaming, shearing and brushing, which are not of much importance.

Conclusion. Carpet factories of all classes embody no subtle hazards, but only those ordinary manufacturing hazards which may be designated as follows:—

In the smyrna class the use of chenille and the consequent large amount of fly which tend to a poor condition as to cleanliness and the rapid spread of a fire; in tapestry, tapestry velvet and axminster, the feature of drying; with ingrain and body brussels, and sometimes with axminster, the feature of Jacquard looms with loom harness and the possibility of gas jets at the looms swinging to or against the harness and igniting it.

There is little tendency to spontaneous ignition in carpet factories of the present day, for the reason that practically all dyeing is done now with aniline colors and this has eliminated the great tendency to spontaneous ignition which existed in former years in yarns dyed in vegetable extracts, particularly cutch brown.

The hazard of shearing and brushing which occurs in tapestry velvet, axminster and wilton is not important, the comparatively small amount of fly produced in this process coming within the range of ordinary care as to cleanliness.

Aside from the main pulley bearings, hot journals are not to be expected.

Considering their inherent hazards and general characteristics, carpet factories may be classified in the order of their desirability from the best to the poorest, in about this order: wilton, body brussels, ingrain, axminster, tapestry, tapestry velvet and smyrna.

A feature that may be noted in carpet factories as well as in any other class of manufacture and which may be readily corrected, is where the clothing of the employees, either in dressing rooms or elsewhere, is hung above or against steam pipes. If it is not feasible to have the clothing hung in another place, wire screening should be placed over the pipes to prevent the clothing from coming in contact with them.

CARPET YARN MILLS.

This class at the present time is not generally found associated with weaving, but in most cases exists as an independent hazard by reason of the general tendency to specialize. Originally carpet yarn was all wool, but competition and the demand for cheaper grades of carpets have brought about the use of wool shoddy (made from old carpet or other rags), cow hair, goat hair, as much as 20% of raw cotton and as much as 10% of jute.

In considering the individual hazard in this class, careful inquiry should always be made as to the character of the stock and the percentages of each that are used; not just what may be in process at the time, but what average proportion of cotton and jute is used, and the maximum proportion of each that may be worked in batches. Also inquire as to the kind of oil used in saponifying the stock in order to make it work smoothly on the cards and spinning mules.

Pickers. These will be found to consist of either or all of the following: rag picker, mixing picker, burr picker, hard-end or yarn-waste picker; all of these are of about equal importance from a fire hazard standpoint and should be in a portion cut off from the main mill.

The stock is generally conveyed from the picker house to the stock boxes at the cards in the main mill by means of a fan through a sheet metal pipe, but an arrangement in this connection which is very objectionable is to pass the stock directly from the mixing picker to the fan, for the reason that by this method a fire in the picker is instantly carried into the main mill. A willow or duster, or both, are generally used, neither of which is important from the viewpoint of fire hazard.

Garnet Machines. These are used for preparing the shoddy from carpet or other rags after they have been run through the rag pickers. They may be located in the mill and comprise about the same hazard as the carding machinery.

Carding Machinery. This is of the ordinary wool or open card type, generally three cards to a set, and where gas is used for lighting it is desirable that the jets in card rooms be encased in glass lanterns, especially where cotton and jute are mixed in the stock. Card strippings, or the dirt mixed with short staple stock, which are combed from the cylinders of the cards one or more times daily, are liable to ignite spontaneously; they

should not be allowed to remain in the mill overnight, but should be removed or run through a willow as soon as possible. After being willowed the strippings are not liable to spontaneous heating and are mixed in with fresh batches of stock.

Spinning Mules. These are of the ordinary type and present only their common hazard, which is the possible heating of the mule-head or main pulley.

Carbonizing. Where old carpet or other rags are used they are frequently carbonized to destroy the cotton fibres in them, and this is accomplished by either wet or dry process.

The wet process comprises the treating with acid solution, which is not hazardous, and washing and drying of the rags. The drier may be an approved "textile" drier, or an old style drier with wire screen over steam pipes or with a fan and steam pipe coil. In any case the arrangements should be investigated and it should be noted whether or not the drier is kept clean.

The dry process of carbonizing consists of subjecting the rags to acid fumes from a small coal furnace, the fumes destroying the cotton fibres in the rags. Drying also forms a part of this process, and the above remarks as to drying arrangements apply here. Note the arrangement of the furnace and its chimney. If there are automatic sprinklers in the portion used for carbonizing, note their condition as to corrosion, because the acid fumes in a very short time so corrode the sprinkler heads as to prevent them from opening freely. This may be overcome by cleaning the heads and dipping them in melted paraffine about once a year.

Hazard. In this class the hazard depends largely on the character of the stock used. Where only wool, wool shoddy, cow hair and goat hair are used the hazard is moderate, notwithstanding the cow hair and goat hair being of short staple, tend to a great amount of fly and give the appearance of a lack of care as to cleanliness. The hazard, however, increases very greatly in proportion as cotton and jute are mixed in the stock.

Where lard oil is used in saponifying there is more of a hazard from spontaneous ignition than where wool oil is used, because the latter is mainly a mineral oil. If, however, the card strippings are willowed promptly, the danger from spontaneous combustion will be reduced to a minimum.

In conclusion, note the stock used, the cut-off between the picker house and the main mill, the manner of handling the card strippings, the kind of oil used on the stock, and the arrangements incident to carbonizing where this feature exists, and, of course, the general condition and care as to cleanliness, which are always important factors.

The Permanent Fireproofing of Cotton Goods.

By William Henry Perkin (Manchester, England).

Abstract of Lecture delivered before the Eighth International Congress of Applied Chemistry.

The problem of the prevention of fire has always been one of the most pressing and at the same time one of the most difficult and perplexing with which mankind has had to deal. It is said that the Romans attempted to render wood fireproof by dipping it in a bath made of vinegar and powdered clay.

This treatment, so strongly reminiscent of processes employed many years afterwards, would no doubt be effective in rendering the wood less liable to inflame, but it can hardly have had wide application, because vinegar, in those days, was not easily obtained in quantity and was consequently an expensive substance. I have made a search in a number of old books with the object of discovering some other of the actual methods used in early times in connection with fireproofing, and the first pamphlet on the subject which I have been able to find dates from 1638, when Nikolas Sabattini published a remarkable paper in which he discussed the need of reform in the administration and construction of the theatres in Italy, and pointed out the danger, which is always present, of fire breaking out on the stage, not only owing to the inflammable nature of the wood employed in the construction of the theatre and for the decorations and scenery but also on account of the inflammability of the cotton material used in the scenery and for the dresses of the players.

He recommends, as a safeguard, that the color used in painting the theatre and scenery should be mixed with clay and gypsum, but says nothing about the fireproofing of the dresses.

At a considerably later date—in 1735—Wild suggested a mixture of alum, borax and sulphuric acid for the same purpose, and in 1740 Fagot, in a paper read before the Academy in Stockholm, recommended a mixture of alum and green vitriol, whereas in the Dictionnaire de l'Industrie, published in the year 1786, there is a paragraph in which it is stated that a mixture of alum, green vitriol and salt is effective in making wood and other material fireproof.

After the disastrous fire in Munich on the 14th of January, 1823, which completely destroyed the Hof and National Theatre, a large

number of experiments were made, with the result that the wood used in the construction of the roof and other parts of the new theatre was painted with several coats of sodium silicate and chalk.

A coating of this kind lasts for many years and, although it does not render the wood absolutely non-inflammable, it has at least this value that the incipient fire, which as a rule begins in quite a small way, meets with resistance at the outset, progresses but slowly and is easily extinguished.

At a somewhat later date it was discovered that wood saturated with other salts, such as, for example, copper sulphate or ammonium phosphate, acquires the property of resisting flame, but of all the salts, zinc chloride seems to be the most efficient for this purpose.

In the first place, zinc chloride has great affinity for, and, therefore, attaches itself readily to, woody fibre, and fibres of all kinds and material saturated with a solution of this salt and then dried are practically non-inflammable. This salt has also this valuable property that it is a powerful antiseptic and therefore very suitable for fireproofing the wood used in the construction of hospitals and other public institutions of a similar nature.

Many disastrous accidents are on record which have been brought about by clothing catching fire: sometimes it is the case of a child whose garments have come in contact with a spark or lighted match, and sometimes disasters of much greater magnitude have resulted from the ignition of costumes made of tow or other inflammable material on the occasion of charity entertainments or fancy dress balls.

It has long been recognized that impregnation with certain salts very much reduces and indeed may entirely destroy the liability of cotton goods to inflame, and of these fireproofing agents I may perhaps be allowed to refer to a few only of the better known and more efficient. If a garment, after washing in the ordinary way, is rinsed in a solution containing alum or is starched with a starch containing a proportion of alum, the material, after drying, shows a marked reluctance to ignite, but this treatment has many drawbacks. In the first place it makes the material very dusty, and secondly the fireproofing is only of a temporary nature, since it is at once removed by contact with water and the process must therefore be repeated every time the goods are washed. Another solution which has been strongly recommended for the same purpose is made up with three parts of ammonium phosphate, two parts of ammonium chloride and one part of ammonium sulphate in about forty parts of water. If the material after washing is impregnated with this solution and dried, or if it is starched with starch made with the solution instead of with water, the dry material only ignites with difficulty, and, as it does not dust and is not prejudicially affected in any other way, this process has been used with advantage not only in connection with wearing material but also for the fireproofing of lace curtains and other inflammable decorations. But in this case also the fireproofing agents employed are all soluble in water, and one washing is sufficient to remove them entirely, leaving the goods

at least as inflammable as before. The process must therefore be repeated every time the goods are washed, and this means expense which, in the long run, becomes considerable.

But a much more serious drawback to processes of this kind is the trouble they entail, since in order to fireproof the garment the washerwoman must have alongside the ordinary wash tub a second tub containing the fireproofing solution, and this complication, added to the expense of the salts, has been shown to be so serious that processes of this kind are quite impracticable, especially in the homes of the poor. Again unless the materials or garments after washing have been dried before immersion in the fireproofing solution, this solution cannot be kept uniform, since each garment being wet when put in leaves the solution weaker than before and therefore of less protective value. To dry each garment between the washing and the fireproofing entails so much trouble and labor and expense that it would obviously prevent any general adoption of the practice. Although the substances I have mentioned, and the salts of ammonium in particular, possess in a high degree the property of rendering material fireproof, there is one substance which confers the property of resisting fire to cotton goods in such a remarkable degree that it has long attracted attention and must be specially mentioned, and that is sodium tungstate.

A piece of muslin soaked in a weak solution of sodium tungstate and then dried is practically non-inflammable, but unfortunately this salt is again so excessively soluble in water that a mere rinsing in clean water is sufficient to remove it completely and the fireproofing is lost. And this applies not only to sodium tungstate but also to all the other salts which have, from time to time, been recommended for fireproofing purposes; the result is not permanent, because the proofing is at once removed when the goods are washed in the ordinary way.

The problem on which I was engaged for several years and which has now been successfully solved, in a very simple manner, was that of attempting to discover some process which not only made the goods non-inflammable but also *permanently* non-inflammable, and the researches on this subject were originally started in connection with flannelette, a material very largely and widely used for clothing, especially by the poorer classes, and one of the most, if not the most, inflammable of all cotton goods.

Flannelette may be briefly described as a kind of calico, the surface of one or both sides of which has been "carded" or "raised" into a nap, the result being that the surface of the calico becomes covered with a fluff of minute fibres somewhat resembling a thin layer of cotton wool. This effect is produced by subjecting the surface of the calico to the action of a series of revolving rollers covered with a vast number of small pieces of sharp steel wire, which tear up the surface, and the material is passed over these rollers over and over again until the required amount of nap has been raised. The result of this superficial covering of nap is—as everybody who has handled flannelette will know—a warm, pleasant and

cosy feel, and this is no doubt due to a covering of air being imprisoned by the minute fibres, thus producing a layer which acts as a non-conductor much in the same way as flannel.

Flannelette is indeed little, if at all, inferior to flannel as a non-conducting material, and as it is very cheap and does not shrink in the wash, it has become very popular and is manufactured in enormous quantities and almost universally used for the clothing of children, especially in the homes of the poorer classes.

But it was not long before its increasing use showed unmistakably that it has one terrible drawback,—the nap, which is its peculiar feature, makes it highly inflammable and much more so than the calico from which it was manufactured.

A fireproofing process to be successful must in the first place not damage the feel or durability of the cloth or cause it to go damp, as so many chemicals do, and it must not make it dusty. It must not affect the colors or the design woven into the cloth or dyed or printed upon it; nothing (such as arsenic antimony, or lead), of a poisonous nature or in any way deleterious to the skin, may be used and the fireproofing must be permanent, that is to say it must not be removed even in the case of a garment which may possibly be washed fifty times or more. Furthermore, in order that it may have a wide application, the process must be cheap. What was really to be aimed at was to treat the flannelette in such a way that it acquired practically the properties of wool, which for all ordinary purposes may be taken as the standard of a safe material. Apart from the other conditions which I have laid down, when one considers the vigor with which the ordinary washerwoman scrubs garments with soap, not infrequently with the assistance of the scrubbing brush, and takes into account the wonderful mechanical appliances now so largely used for washing clothes with the least expenditure of time, it will not be thought surprising that the discovery of a process of fireproofing sufficiently permanent to resist all these conditions seemed at first to be almost an impossibility.

Obviously the substance which is to fulfill these conditions must, in the first place, be insoluble in water, and secondly, in order that it is not liable to be removed by mechanical rubbing and does not render the cloth dusty, it must be fixed in the fibre and not be merely on the surface. I have already explained that when calico is dipped in a dilute solution of sodium tungstate, and then dried, the material possesses in a remarkable degree the property of resisting flame, and then again alum has often been recommended for the same purpose. Now when solutions of sodium tungstate and alum are mixed, an insoluble aluminum tungstate is produced, and it is clear that if this insoluble salt could be fixed in the fibre the material would certainly be fireproofed. It furthermore seemed reasonable to suppose that, as the salt is insoluble in water, it would remain in the fibre even after several washings and therefore that permanent fireproofing might be achieved in this manner.

A piece of flannelette was therefore soaked in sodium tungstate, and

after passing through rollers, to remove the excess of the solution, left for a considerable time in a solution of alum. It was then squeezed, dried and was passed through the same process again, with the result that the material became almost as fire resistant as asbestos. When, however, the piece was thoroughly washed with soap and water, it was most disappointing to find that the greater part of the fireproofing was removed during the first washing, and after several washings the material was little better than the original flannelette.

While this unexpected result was being investigated, it was noticed that aluminum tungstate is soluble in acetic acid and is reprecipitated when the acetic acid is removed by evaporation or by the action of steam, and as the precipitate formed seemed granular in appearance, it was thought that this process, if applied to the flannelette, might yield a better result than the process of double decomposition had done. Accordingly, a solution was made up of sodium tungstate, aluminum sulphate and enough acetic acid to dissolve the precipitate, the flannelette was thoroughly soaked in this solution, dried and then placed in an ordinary steamer and subjected to the action of steam until the odor of acetic acid could no longer be detected.

The material was, of course, non-inflammable, and when it was washed it was found that this property was distinctly more resistant to soap and water than was the case in the first experiment, but after several vigorous washings almost every trace of the fireproofing had disappeared. These negative results seemed therefore to indicate that aluminum tungstate was not suitable for the purpose of permanent fireproofing. On the other hand, the failure of this salt was possibly due to some peculiarities in its specific properties and was not considered valid evidence that other insoluble tungstates might not combine more completely with the fibre and thus resist removal by washing.

A careful examination of the tungstates was therefore made, and such insoluble salts only selected for experiment which, like aluminum tungstate, are colorless, since it is obvious that a fireproofing agent to be of any use must be capable of application to white cloth without staining it. Several hundred pieces of flannelette were treated under the most varied conditions, with all sorts of combinations which it was known would precipitate insoluble tungstates in the fibre, but in no case was a satisfactory result achieved.

However, a fact was noticed which afterwards proved to be of value, and it was this that, of all the salts, the tungstates of zinc and tin seemed to offer the most resistance to washing with soap and water. Thus, when the material had been thoroughly saturated with a solution made up of sodium tungstate, zinc sulphate and enough acetic acid to prevent the precipitation of the zinc tungstate, and the goods after drying were thoroughly steamed, the fireproofing was certainly fixed to some extent, since it required several washings before the material burnt at all freely. But no amount of variation of the conditions produced a really good result, and this combination had therefore to be abandoned. Since the

tungstate proved to be unsuitable to the exacting conditions of the problem, a general examination of almost every variety of salt, including ferrocyanides, aluminates, arseniates, antimoniates, zincates and plumbates was made. Many of these could not be employed in connection with wearing apparel in any case, because of their poisonous nature, but it was thought that this general examination, which lasted several months, might yield some indication of the type of salt likely to prove resistant to soap and water, if, indeed, such type of salt existed at all. And as a matter of fact these experiments did prove to be most valuable, because when the results were all tabulated the generalization gradually became apparent that certain soluble salts, such as aluminates, antimoniates, zincates, and plumbates, in which the oxide of the metal functions as an acid, yielded precipitates especially with zinc and tin salts which exhibited much greater resistance to washing than the commoner insoluble salts, such as barium sulphate or magnesium phosphate. This generalization ultimately led to a very careful examination of the salts of tin, because, as is well known, the oxides of tin dissolve in alkalis to form stannites and stannates, and tin therefore belongs to the class of salts just mentioned, and it very soon became evident that these salts do actually possess the power of combining with the fibre to a greater extent than any of the salts which had previously been experimented with.

In one experiment it was noted that a piece of flannelette, which had first been saturated with a solution of sodium stannate and dried, and afterwards similarly treated with a solution of zinc chloride, was quite non-inflammable. After the sample had been subjected to a vigorous washing with soap and water a considerable amount of the fireproofing still remained, because when a light was applied to the cloth it only ignited with difficulty, burned very slowly, and either went out of itself or was easily extinguished on shaking the material.

This development was so promising that the experiment was repeated in a great variety of ways, but although several results were obtained which were much better than anything which had been seen before, it was disappointing to find that in all the cases the greater part of the fireproofing was lost after repeated washings.

In a later series of experiments the first solution was again sodium stannate, and the second consisted of sodium tungstate, zinc acetate and sufficient acetic acid to prevent precipitation of the zinc tungstate formed. The result in this case was so good, the material being practically as safe as wool, even after repeated washings, that the first commercial permanently fireproofed flannelette which was placed on the market was made on these lines.

It was soon found, however, that the material thus treated had two serious drawbacks; it had a tendency to go damp, and an unpleasant smell of acetic acid remained even though the material had been steamed and washed, after the fireproofing process, before being sent out. And apart from these two faults, the fireproofing was still not sufficiently per-

manent and the cost of the process was too great for it to be considered a satisfactory one.

A further series of careful comparative tests seemed to indicate that the undoubted advance which had been made was mainly due to the use of the stannate, and it was therefore decided to carry out a series of experiments using salts of tin exclusively.

The fabric after being treated with sodium stannate as before, was, in the earlier of these experiments, passed through a fixing bath containing stannous chloride. A very permanent fireproofing was again obtained, but the stannous chloride, being a reducing agent, tended to destroy or affect the colors of the material, and the process would, therefore, be generally applicable only to white cloth.

In order to get over this difficulty stannic chloride was employed, instead of the stannous salt, as the fixing agent, and to avoid any tendering of the material care was taken that the stannic chloride solution should be of such a strength that a little stannate was left unchanged in the material.

An excellent fireproofing was again obtained, for not only did the material show very little tendency to inflame, after it had been washed several times with soap and water, but it had also in such other respects as appearance and feel almost ideal properties, the only objectionable feature being a slight tendency to dust on rubbing and shaking. Now in this particular experiment, in which sodium stannate and stannic chloride had been employed together, the substance which must have been produced in the fibre, and to which the fireproofing must therefore have been due, is stannic oxide, and it seemed clear that this oxide or its hydrate must have some remarkable power of combining with, or attaching itself to, the fibre which enables it to resist removal by washing and rubbing.

But this process still left something to be desired on the score of economy. A certain amount of the tin was undoubtedly wasted, for, in addition to that lost through a portion of the stannate being left unfixed, it was noticed that a considerable amount of the tin oxide, which was formed by the action of the alkali of the stannate on the stannic chloride, was not permanently fixed in the fibres of the material, and was therefore removed during the subsequent washing. Tin is so expensive that, in a process to be commercially successful, this loss must obviously be avoided.

There are many ways in which stannic oxide may be precipitated from sodium stannate, and one of these, commonly used in ordinary analytical chemistry, consists in adding certain soluble salts such as sodium sulphate or ammonium nitrate to the solution of the stannate, when the whole of the tin is precipitated as oxide or hydrate. In order to find out whether some process of this kind would precipitate this oxide in such a condition that it would remain permanently fixed in the fibre, a number of pieces of flannelette were soaked in sodium stannate and, after thoroughly drying, separately passed through various solutions containing sodium or ammonium salts at the ordinary temperature and at temperatures up to

the boiling point. Although, as was to be expected, the results were not uniformly good, a certain degree of permanent fireproofing was always achieved, and consequently the matter was systematically followed up, with the result that a process was gradually evolved which yielded material possessing quite remarkable properties. The process is briefly this:—

The flannelette (or other material) is run through a solution of sodium stannate, having a density of approximately forty-five degrees Tw. in such a manner that it becomes thoroughly impregnated. It is then squeezed to remove the excess of the solution, passed over heated copper drums in order to thoroughly dry it, after which it is run through a solution of ammonium sulphate having a density of about fifteen degrees Tw. and again squeezed and dried.

Apart from the precipitated stannic oxide, the material now contains sodium sulphate, and this is removed by passage through water; the material is then dried and subjected to the ordinary processes of finishing. A long series of trials, carried out under the most stringent conditions, have conclusively proved that material subjected to this process is permanently fireproofed. No amount of washing with hot water and soap will remove the fireproofing agent; or in other words, the property of resisting flame lasts so long as the material itself lasts. This extraordinary property of resisting soap and water seems to me to indicate that the oxide of tin is not present merely as an insoluble precipitate in the cloth, but must have entered into some actual combination with the fibre, yielding a compound which is not broken down by the action of the weak alkali of the soap. But a matter of hardly less importance from the practical point of view is that the material is not only permanently fireproofed by the process I have just described, but it also retains and acquires properties which make it as perfect a material in all other respects as could be desired. In the first place the treatment has no effect on the delicate colors which are now so generally employed in connection with the manufacture of flannelette and other cotton goods, and very careful experiments have demonstrated the fact that the insoluble tin compound in the fibre has not the slightest deleterious action on the most delicate skin. In addition, the presence of the tin compound in the pores gives the cloth a softer and fuller feel than that of the original flannelette, and what perhaps is the most unexpected result is the fact that the material is considerably strengthened by the process.

A series of tests made by the Manchester Chamber of Commerce proved that the tensile strength of flannelette is increased nearly twenty per cent as the result of the introduction of the tin compound into the fibre.

Further and very exhaustive tests made at the Municipal School of Technology, Manchester, on a machine specially designed for testing the wearing properties of fabrics, showed an even greater gain in durability in the case of the fireproofed flannelette. These separate and independent tests conclusively showed that the increase in strength and durability was approximately equal to the cost of the fireproofing treatment, so that gar-

ments made from the permanently fireproofed flannelette are as a matter of fact no dearer than those made from ordinary flannelette and are at the same time as safe as if made from flannel.

This permanently fireproofed flannelette is now manufactured on the large scale by Messrs. Whipp Bros. and Tod in Manchester, under the name of "Non-Flam," and although its introduction has been slow, it is being increasingly used and will, in all probability, ultimately entirely replace the ordinary inflammable variety. One of the difficulties experienced in connection with its general introduction is the fact that, owing to the high price of tin, which is now quoted at about $1,050 per ton, the cost of the process is not inconsiderable but, even with tin at this high price, the extra cost is not more than two cents per yard or about three to four cents for a child's garment.

It is hardly necessary for me to say that this process can be applied to any cotton fabric and is especially valuable in connection with muslin, because this material is so often used, especially on the stage, for dresses which, on account of their flimsy nature, are naturally highly inflammable. Another direction in which the process may be used with great advantage is in connection with lace curtains. Many disastrous fires have occurred by reason of the ignition of lace curtains, and there can be no doubt that the greater majority of these would have been avoided if the curtains had been treated by the "Non-Flam" process.

It seems to me that it is obvious that, if this process or some other process capable of giving the same protection from fire, were adopted in the case of all inflammable cotton goods and especially in the case of material used for garments, many disastrous fires and the appalling loss of life, especially among young children, might be avoided.

Spontaneous Combustion.

By **William Warren Moore** (Member N. F. P. A.)

BIBLIOGRAPHY.

"Fire and Explosion Risk"	*Dr. Von Schwartz*
"Spontaneous Combustion"	*C. A. Hexamer*
"The Chemistry of Fire and Fire Prevention"	*Herbert Ingle and Harry Ingle*
"Insurance Engineering"	Vols. I, V, XVI.
"National Fire Protection Association Quarterly"	

INTRODUCTION.

Spontaneous combustion was for a long time the attributed cause and effect of all unknown incendiarism. It was the attributed explanation for unanalyzable phenomena in fire technology. Under this heading were classified those causes termed accidental in their nature, those causes defined as chemical unions, and lastly those of true slow combustion. But to give the subject an analytical generalized classification, the definition of this familiar phenomenon will include those which are caused by what the chemists call combustion; that is, a union with oxygen. This incorporates all cases of combustion brought about by chemical, electrical, biological, or physical processes, independent of any source of external heat or light.

Dr. Von Schwartz in his treatment of the subject has classified spontaneous combustion under two distinct heads; namely, those cases in which ignition is preceded by spontaneous heating, and a slow combustion ensues, and those cases which are practically explosive in character. The former class he terms "chronic," the latter "acute." Though the acute class usually embodies a most dangerous and highly sensitive group of materials, the fact that the inherent danger is recognized and consequently provided for causes them to be judged less objectionable than those of the chronic class, where long internal carbonization or calcination might ensue for days and months, only to manifest itself in a conflagration at the most unexpected moment.

Acute spontaneous ignition is applied to such substances as are termed "pyrophorous" in their nature, in which condition little if any abnormal circumstances may incite combustion and ignition. Chronic spontaneous combustion may extend in some cases over a period of two or three months, a great deal depending on the inherent circumstances and the bulk of storage.

Organic bodies which are subject to spontaneous ignition at ordinary temperatures must, in the first place, be in an oxidation medium, for upon the oxygen element depends the whole reaction. In the second place, it must be in the presence of some carbonaceous, combustible material, for ignition cannot take place without a supporter of combustion. In the third place, there must be a minimum temperature limit, in order that the cooling effect might not counteract. And finally, moisture is in some cases essential as an incentive to the resultant reaction. The necessity of such conditions is undeniable, but to endeavor to correlate these requirements to all conditions is inadmissible.

The classification of the various kinds of spontaneous combustion is impossible in the real sense of the word. Each case requires its special treatment, and the treatment must be adaptable to the varying condition of circumstances. In fact, the conditions themselves are in most cases uncontrollable, and any attempt to apply cut and dried regulations is unpractical. For this reason, preventive methods must be obtained by observation and experience, and applied specifically.

Spontaneous heating and spontaneous ignition has been already observed in practice to occur in the following substances:—

Coal, lignite, briquettes, coke, lampblack, peat.

Wood, sawdust, dye-woods, wood charcoal, cork dust, insulating materials, leather.

Colors, varnishes, resins, lacquers, oils, dryers, fats, disinfecting powder, lacquered substances, oil cloth.

Fire lighters, matches, gas purifying materials, soda residues, slag heaps.

Metallic powders, drill turnings, burnt lime, carbides, carriers of oxygen.

Nitric acid, nitro compounds, sulphur compounds.

Artificial manures, stall manures, fish guano, superphosphates.

Hay, clover, grass, malt, malt culms, cereal grains, bran, hops, tobacco, seeds, concentrated fodder and mixtures of the same.

Wool, cotton, silk, flax, hemp, jute, tow, rope.

Oil rags, greasy cloth, polishing rags, polishing discs (buffing wheels), article of clothing in a greasy or dusty condition.

Naturally there are certain of these above mentioned susceptibles which, because of their similarity of structure, or behavior under similar conditions, group themselves together. It has been deemed advisable for this reason to treat the subject specifically under six heads: coal, wood, fibrous material, agricultural products, metals, and miscellaneous.

I. COAL.

Because of the great quantities of coal stored all over the world, and the interests in its preservation, much time and thought has been given to ascertain the inherent danger of, and to develop preventive measures against, spontaneous ignition. As yet, however, on account of the great variety of coal composition, and of treatments by experimenters, no universal standards have been adopted. Experience in practice and experimental facts would in many cases appear contradictory, owing to the innumerable causes and conditions conducive to combustion.

*"Coal is the product of the decomposition of vegetable matter under special conditions." It is in itself a supporter of combustion and besides contains properties which in themselves are spontaneously ignitible; among which iron sulphides (pyrites) have been a source of trouble. Inflammable liquids such as ligroin, benzol, etc., together with explosive gases, as hydrogen, methane and carbon monoxide, render this body inherently dangerous in composition. The subject itself, therefore, is in every way favorably constructed to be subjected to just such actions as those which cause spontaneous heating and spontaneous ignition.

Under the subject of coal the intention is to treat those materials which, while not sometimes classed as such, are in general influenced by the same conditions. This will include anthracite and bituminous coals, all kinds of carbon classed under the name of coal, coke, and briquettes. These various compounds differ principally in the percentage composition of their structure, and their susceptibility to conditions. Each in themselves varies somewhat in its behavior, according to the locality in which it is buried.

Considerable evidence has been obtained on the susceptibility of coal to conditions. In view of this fact it can be stated definitely that the factors which influence spontaneous combustion are moisture, ventilation, presence of sulphur in the shape of pyrites, and the degree of pulverization. Of these four, one may under certain conditions be of more importance than another. For example, moisture without the presence of sulphur would act as a preventive to spontaneous ignition. † Professor Threfall in his investigation of the subject went so far as to assert that moisture in all cases retarded any heating process, and based his finding on the chemical knowledge that heat would be absorbed in the evaporation of water or moisture occurrent among coal. He went further to prove his point by experiment, but his analysis was evidently confined to a particular coal and therefore unworthy of consideration.

The above may serve as an example of how narrow some opinions have been on the subject. To attribute all cases or even any case of spontaneous combustion in coal to one cause would be inconsistent.

‡ Eleven causes are known, based on practical experiments, tests, and observation:—

1. The presence of sulphur (as pyrites).
2. The presence of coal gas (marsh gas).
3. The absorption of oxygen by the coal.
4. Weathering.
5. Porosity.
6. The formation of dust.
7. Wet.
8. The application of heat (from 100° F. upward).
9. Defective ventilation, surface cooling.
10. Internal ventilation by formation of cavities in the heaps.
11. The presence of pyrophoric, heat generating, extraneous substances.

* Hexamer.
† Coal fire in the steamship Walter H. Wilson, "Ins. Eng." Vol. I.
‡ Von Schwartz.

From the above we may assume two general theories. First, the absorption and condensation of atmospheric oxygen in its pores causing a pyrophorous condition and excessive heating. Second, the oxidation of the oxidizable sulphur compounds, chiefly pyrites. These are undoubtedly the main and generally accepted causes of a majority of coal storage fires, but we cannot say that these are the only reasons that should be attributed to this phenomenon.

The occlusion of oxygen is a very important factor in spontaneous combustion. After the coal has been mined, the fresh product gives off a methane gas, familiarly known as "fire damp." Atmospheric oxygen is substituted, the coal being known to absorb from five to ten per cent (of its own weight). Much heat is generated by the oxidation of the various constituents present, and this only tends to accelerate its own action. The rapidity of the reaction is considerably aided by warmth and fine subdivision.

The oxidation of the sulphur compounds in coal is a very important attribute to combustion in certain grades of the product. This reaction occurs in the presence of moisture. Heat is liberated, which tends to cause dry distillation, much danger being present in the escape of the volatile, explosive constituents.

To generalize the conditions most favorable to the above reactions: In the first place spontaneous ignition is improbable in small heaps, for the phenomenon depends upon the insulating power of the surrounding medium, in order to accumulate heat. Secondly, moisture must be present in the case of pyritic coals to promulgate its reaction. Thirdly, the coal must be of sufficient porosity so that the oxidation reaction might proceed fast enough to generate more heat than can be radiated; and lastly, the presence of coal dust tends to accelerate any reaction, yielding a greater surface to the active agent and giving the product a greater absorptive power.

To sum up the essentials of this brief discussion, it is concluded that there are two stages of spontaneous combustion in coal—absorption and oxidation. Preliminary heating is caused by the former through a physical phenomenon, chemical reaction taking place, which increases in intensity with the temperature. Conditions tending to increase the intensity of absorption, and the supply of oxygen, are productive of spontaneous combustion. This depends on surface exposure and attraction. Conditions productive of a rapid oxidation, such as fine subdivision offering a larger surface, tend to cause spontaneous combustion. Coal placed in large heaps causes more accumulative heating to the interior mass and therefore fosters combustion and ignition. Dampness may or may not be conducive to combustion. If coal contains much pyrites which decomposes in the presence of moisture, and at the same time the absorptive power of the coal is small, water should be eliminated as far as possible. When, however, the pyrites is small in per cent and the absorptive power of the coal is large, dampness would tend to prevent spontaneous ignition.

Preventive methods are many in number, but few in principle. They all involve the ideas of ventilation, proper apportionment, and sprinkling of the non-pyritic coal. Thermostats have been employed as detective devices. In a paper read before the British Society of Arts, Professor Lewis suggested an ingenious device. *"Steel bombs filled with liquid CO_2 placed in various parts of the coal pile. The bombs are provided with a fusible plug which melts at 93° C. If the temperature of the coal pile rises to the degree at which ignition would probably take place, the plug would melt and the carbonic acid escape under pressure and produce by evaporation a considerable cooling effect."

II. WOOD.

Wood is the typical organic substance, and its treatment in reference to combustibility may be taken as generally characteristic of those which are most intimately connected with it in their property relations. Because of these existing relations, the intention is to treat also under this heading such substances as sawdust, charcoal, and lampblack. All of these vegetable materials might have logically been discussed under coal, but the division seems justifiable on the grounds of their relative importance.

Wood is a substance whose general properties and characteristics need not be explained even to the most unscientific mind, but doubt must be expressed as to the general knowledge of its behavior when subjected to abnormal heating. Natural moisture in wood, which ranges from one to twenty-five per cent, is first driven out by evaporation. Further heating causes the resinous materials to exhibit themselves. External charring then commences and gaseous products such as carbon monoxide, dioxide, and hydrocarbons are expelled. This occurs between the temperatures of 150° C. to 230° C. Pyrophoric carbon is then formed up to a temperature of 270° C. The limitation of the subject matter demands a termination at this point.

Carbon in the pyrophoric condition is the most hazardous condition of the material with which we are dealing. A peculiar property of this substance is that though this condition is reached at 270° C. it will ignite at as low a temperature as 150° C. Occlusion of oxygen is given as the inherent cause of this phenomenon. This is made possible by the porosity of the substance in question being intensified by the expulsion of the water and the volatile aromatic constituents. Preventive methods, such as impregnating the wood with antipyrenes, aid materially in counteracting any effect to cause pyrophorous carbon to be formed and spontaneous ignition taking place.

Sawdust has a tendency to ignite when stored in large heaps and impregnated with foreign material such as vegetable oils, glue, organic dyes, etc. Nitric acid will cause sawdust to ignite. Dampness, also, is very conducive to spontaneous heating. In the latter case, putrefaction sometimes takes place, liberating phosphoretted hydrogen, which causes

ignition. The proper distribution of the piles in which such refuse is stored serves as a very simple preventive method.

Charcoal and Lampblack are the incomplete combustion products of burnt materials such as wood, bone, organic matter, tar, mineral oils, etc. The industry has grown to considerable importance, and the manufacture of these products on a large scale has caused their storage to become a problem. It is this phase of the subject that is to be treated.

Charcoal is characterized by great porosity, and therefore has the property of absorbing gases to a greater or less extent. The occlusion of oxygen is the predominating factor in the spontaneous heating and ignition of this substance. This affinity for the oxidizing element is always accompanied by considerable heat generation, which incites an action that leads to fire.

Moisture is known to aid the spontaneous ignition of charcoal. It is said to drive out the absorbed gases, and when dried, leaves the pores again empty and subject to this occlusion reaction. There is then no danger from this source as long as the water occupies the pores. Other conditions which cause ignition are, fats and oily materials, fine subdivision, presence of hygroscopic substances and oxygen carriers.

Lampblack is subjected to the same conditions only to a greater degree. It has a greater power of retaining heat than any other carbon. Ignition is fostered by its oily character. Lampblack from tar, tar oils, mineral oils, coal, lignite, and peat contains sulphur which on contact with iron will cause spontaneous ignition. Its storage in large heaps should be avoided as far as possible.

In conclusion it must be said that the most important factor to be reckoned with is the occlusion of oxygen and other gases. Wood subjected to continuus heating will form a pyrophoric carbon which is liable to ignite spontaneously at low temperatures. The storing of sawdust, charcoal and lampblack in large heaps fosters internal heating and combustion. Degree of purity and fine subdivisions play a considerable part in the reaction. Careful handling of this class will practically eliminate danger.

III. FIBROUS MATERIAL.

Because of the breadth of the subject under consideration it would seem desirable to specify briefly the specific materials to be dealt with. By fibrous materials in this connection is meant such products as wool, silk, cotton, jute, hemp, flax, tow, shoddy, etc. Of these, two classes present themselves, and give a distinct means of discrimination between the dangerous and non-dangerous fibres. Animal fibrous materials are in general much less susceptible to spontaneous ignition than the vegetable product, because of the physical constitution of their fibres. It is most natural to suppose that hollow fibres are more dangerous in their behavior toward fire than solid fibres, because of their tendency to absorb oxidizing foreign materials. Again, animal fibres when ignited will not support combustion, while vegetable fibres in general will smolder and retain

fire. The impregnation of this class of materials with oils forms the most interesting study of the subject of spontaneous ignition.

A piece of cotton waste of itself will not take fire. A cup full of linseed oil will become rancid on exposure, little heat being perceptible in the reaction. Saturate the waste with the oil and spontaneous ignition will occur under normal conditions within sixteen hours. The results are spectacular but easily explained. The waste on being impregnated with the oxidizing oil disseminates it over a large surface, and absorbs it in the pores. It thus becomes exposed to a large volume of oxygen, and the reaction that ensues generates considerable heat which is accumulative on account of the insulating powers of the waste. This heat accelerates further reaction and finally the intensity is great enough to ignite the readily combustible medium.

Experiments carried on by R. Kissling have revealed the following facts in reference to this action of "auto oxidation." The heat generated is dependent upon,—

1. The porosity of the material, or the area of contact between the oil and the air.
2. The oxidizing quality of the oil.
3. The ventilation of the object.
4. The application of external heat.
5. The absorption power of the pores for oxygen.
6. The degree of rancidity of the oil.

Animal and vegetable fibres are both susceptible to the action of auto oxidation, but mineral fibres, such as spun glass, mineral wool, etc., are not. Almost all fats and oils will produce such a reaction, though in some to such a slight degree that they can well be classed as inactive. It is safe to say that mineral oils in general, because of their negligible affinity for oxygen, are not objectionable when absorbed in fibrous materials. This fact affords a means of reducing the danger of spontaneous ignition with other oils, by mixing them with the mineral product.

Owing to the many varieties of fibrous materials, a classification of the dangerous oils has been rendered almost impossible. Dr. Von Schwartz has attempted this, however, by taking advantage of the fact that their dangerous property is in direct ratio with their iodine absorption power.

Vegetable		Animal	
Oil	Iodine Value	Oil	Iodine Value
Linseed	170	Codliver	140
Hemp	150	Seal	127
Nut	146	Japan Liver	120
Poppy	138	Goose	71
Olein	138	Bone	68

To sum up the preceding paragraphs, it is concluded that animal and vegetable fibres when saturated with animal or vegetable oil are subject to spontaneous heating and spontaneous ignition; that vegetable fibres are more susceptible to this action than animal fibres; that vegetable

oils are more active in this regard than animal oils. Preventive measures, such as mixing a dangerous oil and a mineral oil, will reduce the action to a considerable extent. Where the presence of oily waste is a necessity, an approved metal waste can should be provided as a receptacle, and care used in the disposal of the contents. A reference to the appendix will tend to show the importance of such a provision, for the fire record has been unduly increased by the spontaneous ignition of oily waste and refuse.

IV. AGRICULTURAL PRODUCTS.

Under this heading it might be well to make a general classification as "fodders" and include such materials as grass, hay, straw, bran, clover, cereals, rice, and in fact all the products of the field. The phenomena of spontaneous combustion in this class of materials exhibit considerable variation according to their specific natures and external influences such as method of storage, moisture, exposure, etc. It is safe to say in general that there is no danger when these materials are in the fresh state; but their highly inflammable character in a dry state renders them very susceptible to ignition. The real danger of spontaneous ignition occurs when the damp product is piled in huge heaps. Careful study of the nature of the reaction which ensues under these conditions reveals a very interesting phenomenon, and a discrimination between spontaneous decay and spontaneous combustion becomes necessary.

In the process which leads to combustion, the product is changed chemically and physically by the bacteriological action. First, fermentation and micro-organic action raises the temperature to 132° F. Second, the products of fermentation, such as fats, albumen, and carbohydrates, become charred, and the temperature reaches 212° F. Third, chemical action sets in, involving the cellulose, and a temperature of 265° F. may be reached, causing ignition to take place.

In regard to moisture present, even a very small section of damp grain might start a serious reaction. The most dangerous condition arises, of course, when this moist product is situated at the bottom or in the middle of the storage, where the generated heat has no chance to escape. Wooden timbers used as props or pillars in fodder heaps have been known to cause fires, due to the concentration of heat which naturally seeks an escape, with this flue as a common center. The flow of heat that results is also accompanied by moisture and may cause a reaction to start in the surrounding materials, and add to the generation.

Manures, since they invariably are stored in the open, need little discussion. The processes which may lead to spontaneous ignition and combustion are chemical and biological ones. However, the medium is not usually combustible, and fires therein are an extremely rare occurrence. Artificial fertilizers in some instances are chemically active enough to cause trouble if not handled in the proper manner.

Straw is very susceptible to spontaneous ignition, since it usually contains weeds which dry more slowly than the straw itself. If treated

with ammonia water or nitric acid, straw will invariably take fire. *Hops* ferment with considerable evolution of heat. They also contain what is known as "lupulin" which when damp exhibits a tendency to ignite in spontaneously. *Grains and seeds*, though less liable to cause trouble than the above mentioned, are not altogether harmless.

The prevalent condition which incites fermentation and spontaneous ignition in agricultural products is moisture in large heaps of the material. Precautions to prevent fire are those which will tend to exclude vegetable dampness from the storage. Should this be impossible the next alternative is to properly watch the fodder and turn it over to prevent the accumulation of heat.

V. METALS.

Metals are commonly considered incombustible. This, however, is a misconception. Most metals as such *are* combustible, and when considered with their compounds form a class of materials which must be recognized as dangerous and dealt with accordingly. We have previously referred to "chronic" spontaneous combustion where the action has been slow, gradually building up sufficient heat to ignite the surrounding medium. In metals another class of spontaneous combustion pre-eminently exists in which the action is "acute," and in some cases violent, being more in the nature of an explosion.

Metals are divided into two classes, namely, "light" and "heavy," the former class being in most cases the more dangerous. Some metals such as potassium, sodium, magnesium, aluminum, iron and cobalt, ignite in air, and are therefore combustible in themselves. Some, such as iron, aluminum, zinc, cadmium, antimony, and cobalt, exhibit this tendency to spontaneously ignite under normal conditions when in a finely divided state. Others, such as magnesium, zinc, potassium, sodium, rubidium, cadmium and manganese, decompose water into its two elements, oxygen and hydrogen, and the heat formed spontaneously explodes the oxyhydrogen product. This action also occurs in the case of iron when immersed in water in a glowing state. Others of the above named metals will cause such an action when in a finely divided state, or when the water is hot. Finally, certain metals such as cobalt, iron, zinc, indium, nickel, manganese, copper, tin and others of less importance, give off the oxyhydrogen gas when immersed in hydrochloric, or sulphuric acid. Alloys and amalgams inherit the properties of their ingredients.

Some compounds of potassium and sodium are in some cases found to be as dangerous as the elements themselves. Of those which are considered spontaneously ignitible are potassium chlorate, potassium hydride, and sodium carbide. Calcium compounds such as calcium nitride, calcium sulphide and calcium carbide will become dangerous in the presence of water. Calcium carbonate (quicklime) has properties familiar to most everyone. Aluminum triethyl, trimethyl and tripropyl ignite spontaneously in air. Zinc also is rich in dangerous compounds.

Iron has many dangerous characteristics. It is pyrophoric in a finely

divided state and ignites spontaneously when fresh. The danger from this source lies in the fact that iron filings and turning from metal workers' establishments are liable to be piled against combustible material. Iron sulphide has already been mentioned under the name of pyrites existing in coal. Iron carbide and ferrous oxide have been known to cause fires.

Bronze powders are pulverized metal dusts which may be either "monometallic" or otherwise. Because of the extensive surface subjected to the action of oxygen, and because of their great affinity for this element, they are considered dangerous. Excessive heating is caused in the presence of water, acids, or other oxygen-carrying materials. For this reason great care should be exercised in their storage and preparation, and they should always be kept in a cool, dry place.

Since some metals under certain conditions and circumstances are dangerously exposed and may be subject to explosive decomposition, they must be considered of equal importance with any other group of susceptibles. Their compounds, especially the sulphides, are in many cases most liable to cause trouble. Metals in a finely divided state are dangerous because of their great affinity for oxygen. In this condition some metals liberate the oxyhydrogen gas from water and acid, causing explosions. A dry location and atmosphere is therefore essential to their safety.

VI. MISCELLANEOUS.

In the endeavor to classify the phenomena of spontaneous combustion under the various heads, it has been necessary to give importance to those groups of materials which should by virtue of their relativity be given preference. Other instances of more or less importance will be grouped under this heading and the fact of the existing danger merely mentioned.

Alum calcined with charcoal may ignite spontaneously owing to the presence of potassium sulphide; also alum shale contains pyrites and bitumen and is subject to spontaneous ignition in presence of moisture.

When flashlight powders are impregnated with benzol or ether to accelerate ignition, spontaneous ignition is likely to occur.

In storage of fire lighters, and phosphorus matches, danger of spontaneous ignition is prevalent; phosphoretted hydrogen is subjected to ignition in air.

Carbon disulphide ignites spontaneously between 293° F. and 338° F.

Ether ignites spontaneously with permanganic acid.

Spontaneous ignition may result from adding turpentine to hot asphalt.

Colophony (violin resin) is liable to spontaneously ignite when placed in intimate contact with oxygen, ozone or carriers of oxygen.

Driers used to hasten drying of varnish form substances which are spontaneously ignitible.

CONCLUSION.

It can be readily seen that the subject as here treated only briefly brings out the important features of the phenomena of spontaneous combustion, as related to the various classes of materials subject to such a reaction. The intricate nature of the chemical, biological and physical processes involved in the generation of heat and combustion in these materials would call for a more complete analysis of their specific cases, but it has been the intention of the writer to generalize as much as possible rather than specialize, and to relate only the important features of their chemistry. The discussions in many instances are theoretical, but experiments along analagous lines would seem to justify the conclusions. Spontaneous ignition and combustion are definitely determined reactions, subject not only to analysis, but also to regulation and prevention.

CLASSIFICATION OF FIRES AND THEIR CAUSES.

(Data from N. F. P. A. Quarterly.)

Manufacture	Stock.	Sweepings and Rubbish.	Overalls and Clothing.	Oily Waste.	Special to the Process.	Total Number Fires.	No. Fires Caused by S. I.	Per cent of Fires Caused by S. I.
Shoddy Mills	1	..	..	..	2	90	3	3.33
Waste and Baling Mills	1	..	..	6	1	114	8	7.00
Paint and Varnish Factories	10	7	5	..	1	95	23	24 2
Musical Instruments	1	3	4	15	1	91	24	26.4
Cotton Mills	56	..	..	68	17	4510	141	3.14
Woolen Mills	5	4	9	13	14	750	45	6.00
Drug Houses	..	5	..	4	11	131	20	15.25
Knitting Mills	..	1	1	8	4	462	14	3.03
Oil Cloth and Linoleum Works	3	1	..	..	3	60	7	11.7
Clothing Factories	2	8	..	16	4	125	30	24
Department Stores	..	19	..	4	7	122	30	24.6
Metal Workers	..	30	..	72	30	818	132	16.1
Cordage Works	3	..	..	..	..	149	3	2
Total	82	78	19	206	95	7517	480	6.4

Department of Fire Record.

By J. Albert Robinson, Superintendent.

The Shoe Factory Fire Record.

In the thirty-five fire records which have been published by the National Fire Protection Association only three have exceeded the present record on Shoe Factories, and none of the remainder has approached this record in the number of fires which were available for analysis. The statistics presented in the following record may be accepted, therefore, as an exceptionally truthful presentation of the conditions obtaining in this industry as regards the causes and losses by fire and the efficiency of automatic sprinkler protection in this class.

It is an interesting commentary on the regard in which automatic sprinklers are held in this industry that 577 fires in the total record of 632, or over ninety-one per cent, occurred in some portion of sprinklered properties. A number of our older reports are of fires which then occurred in unsprinklered factories that probably have long since been equipped with automatic protection. Less than four per cent of the fires comprising our record occurred in unsprinklered portions of protected plants. In thirty-four per cent of all fires occurring under sprinkler protection the heat was either not sufficient to operate the sprinklers or the available means at hand for extinguishing the fires were used so promptly that the sprinklers were given no opportunity to operate. This is a remarkable commentary on the efficacy of minor inside protection.

Unlike the conditions which have been shown to exist in a number of industries, the greatest number of shoe factory fires were due to special hazards, the number of which bore a relation to common hazard fires of five to four. The large losses which were due to either cause were equally distributed between the two.

Over half of the special hazard fires were due to the handling and use of rubber cement, the finishing processes and the presence of cutting board scrapings, comprising respectively about twenty-five per cent, twenty per cent and eleven per cent of these fires. A study of these

causes shows that certain occupational hazards must of necessity be encountered in shoe factories. It becomes, therefore, vitally important to discover satisfactory means of prevention or elimination, and to determine the efficiency of automatic protection under the exigencies that are so apt to prevail. In the fires due to the cementing hazard, which occurred in sprinklered properties, eighty-five per cent were extinguished or practically extinguished by the operation of the sprinklers and the remainder were held in check. As there was but one large loss due to this cause, and the remainder were equally divided between small loss fires and fires where no claim for insurance indemnity was made, the record shows that nearly fifty per cent of these fires were successfully extinguished without appreciable damage, and many more without any loss of consequence.

The location of a fire in a shoe factory has much to do with the magnitude of the loss, owing to the presence of quantities of material very susceptible to excessive water damage. Among the prominent special hazard causes which one would expect to produce fires resulting in a considerable loss, especially in a factory equipped with automatic sprinklers, is that of the spontaneous ignition of cutting board scrapings, the process causing this hazard being generally located on the top floor of the ordinary factory. The statistics seem to show the truth of this assertion. In the fires due to this hazard which occurred in sprinklered properties, all but one were extinguished without the necessity of making a claim for insurance indemnity; twenty-four per cent resulted in a large loss, and in the remaining cases an unnecessary loss resulted, although eighty per cent of these fires were entirely extinguished by the operation of the sprinklers.

The infrequency of fires resulting from waterproofing processes speaks volumes for the power of the fire insurance interests through their engineering bodies to use their talents in an educational propaganda that can correct and even eliminate a serious hazard. The use of viscol, which at one time nearly created a panic in the underwriting fraternity, is now nearly an obsolete hazard.

The common hazard causes of fires were well distributed among the usual causes, but the presence of rubbish and sweepings and the prevalence of smoking were the principal causes, being responsible for about twenty-one per cent and sixteen per cent, respectively, of this class of fires.

A large loss resulted in twelve per cent of all the fires and in eleven per cent of the fires that occurred where the sprinklers operated. The resultant damage due to lack of protection on the one hand would seem to be offset by too much protection, or at least too much water, on the other hand. In the large loss fires where the sprinklers were called upon, sixty-two per cent of the large losses were due to a needless water damage and twenty-nine per cent were due to exposure fires.

Slightly over three per cent of all fires were due to exposure. Of these fires, seventy per cent resulted in a large loss, twenty per cent in a small

loss and ten per cent in no claim for insurance indemnity. About two and one-half per cent of the fires occurring where the sprinklers operated were due to exposure. All of these resulted in a large loss. The operation of the open sprinklers in two prominent cases demonstrated the need of ample water to attain such protection, and the futility of such protection where the mains and pressure are not adequate. Some fire protection engineers contend that open sprinkler supplies should be under control of the building occupant, and advocate that the rules governing the installation of open sprinklers should be so modified as to allow the connection of open sprinklers to secondary water supplies such as gravity tanks of suitable capacity or fire pumps.

About ninety-five per cent of all fires which occurred in plants equipped with sprinklers occurred in plants equipped with wet systems. Although but five per cent of the fires happened in plants equipped with dry systems, the record was good. In eighty-five per cent of these cases the fire was extinguished by the operation of the sprinklers and no case of sprinkler failure was reported. The average pressure was about two thirds that of the wet system and the average number of heads which opened more than twice that for wet systems. The relation between the dry systems and the loss results was practically the same as for wet systems.

Approximately seventy-seven per cent of all fires were practically or entirely extinguished, twenty per cent held in check and in three per cent of the cases the work of the sprinkler equipment was unsatisfactory.

The average pressure in those cases where the fires were practically extinguished was sixty-five pounds; in those held in check fifty-seven pounds, and forty-one pounds in the unsatisfactory cases. In the cases where no claim for insurance indemnity resulted, the average pressure was sixty-nine pounds; in those where the loss was small sixty-three pounds, and fifty-two pounds where the loss was large. These figures are interesting because they exhibit no radical tendencies. The pressures are well recognized as being efficient and are those most commonly met with in practice.

An average of 3.14 heads opened in all cases, excluding the fires where the work of the sprinklers was unsatisfactory. In the cases where the fires were extinguished, an average of 2.2 heads opened, and an average of 6.8 heads opened in the cases where fire was held in check. In the cases where no claim for insurance indemnity resulted, the average number of heads which opened was 1.6; where a small loss resulted, the average was 2.6, and where a large loss resulted, the average was 12.3 heads per fire. The last figure is interesting in view of the fact that such a large percentage of the causes for large loss was due to water damage.

Of all the fires which occurred in sprinklered plants, twenty-two per cent resulted in no claim for insurance indemnity, while in ten per cent of the cases a large loss resulted. On the other hand, in the unsprinklered plants only five per cent of the fires resulted in no claim for insur-

ance indemnity and a large loss resulted in thirty-five per cent of the fires. In those cases where the sprinklers practically or entirely extinguished fire, six per cent resulted in a large loss. In those cases where the work of the sprinklers held fire in check, fifteen per cent of the fires resulted in a large loss. In those cases where the work of the sprinklers was unsatisfactory, ninety-two per cent resulted in a large loss, and a small loss occurred in the remainder. Eleven per cent of all fires occurring in sprinklered plants resulted in a large loss and in twenty-one per cent of the cases no claim was made for insurance indemnity.

The relation of the action of sprinkler protection in shoe factories as compared to the combined figures for all classes is very instructive. Seven per cent more of the shoe factory fires were completely extinguished by the operation of sprinklers than the general average, and the failures were less by two per cent, a relative difference of forty per cent in favor of shoe factories. There were fifty-five per cent of the shoe factory fires extinguished by the operation of one sprinkler as against thirty per cent for the general average. Also eighty-eight per cent of the fires were extinguishd by five or less heads, while the general average was sixty-eight per cent extinguished by a similar number of heads.

Secondary water supplies were of negligible consequence in these fires. Water pails and chemical extinguishers were principally used where no sprinklers operated. The use of wet burlaps, etc., was also very serviceable in handling incipient cement fires. Of very great significance is the table showing the amount of water used by automatic sprinklers, in which it will be observed that the average quantity for sixty-five cases in which the sprinklers extinguished the fire was but 1,500 gallons. In twelve cases it was estimated that 500 gallons were used and in another twelve cases 1,000 gallons were used.

Shoe Factories---Fire Record.

Total Number of Fires, 632.

1. CLASSIFICATION OF CAUSES.

Summary.

Common Causes.

	No. of Fires.	Per Cent of Common Hazards.	Per Cent of Known Causes.
Lighting	20	9.3	3.9
Heating	7	3.2	1.4
Power	24	11.1	4.7
Boilers and Fuel	26	12.0	5.0
Chimneys and Flues	1	0.5	0.2
Sparks	4	1.8	0.8
Fourth of July	2	0.9	0.4
Lightning	8	3.7	1.6
Smoking	34	15.8	6.7
Matches	11	5.1	2.2
Rubbish and Sweepings	45	20.8	8.8
Spontaneous Ignition	22	10.2	4.3
Careless Use of Volatiles	4	1.9	0.8
Carelessness of Employees	3	1.4	0.6
Electric Currents	5	2.3	1.0
Total	216	100	

Special Hazard Causes.

	No. of Fires.	Per Cent of Special Hazards.	Per Cent of Known Causes.
Cementing	65	25.0	12.7
Finishing	51	19.6	10.0
Cutting Board Scrapings	28	10.7	5.5
Making	23	8.8	4.5
Buffing	18	7.0	3.5
Waste Chute	16	6.1	3.1
Naphtha Black	12	4.6	2.3
Cement House Fires	11	4.2	2.2
Volatiles and Combustibles	10	3.8	2.0

	No. of Fires.	Per Cent of Special Hazards.	Per Cent of Known Causes.
Waterproofing	5	1.9	1.0
Heating Compound	4	1.5	0.8
Ironing	3	1.1	0.6
Pounding	3	1.1	0.6
Singeing	3	1.1	0.6
Stamping	2	0.8	0.4
Scouring	2	0.8	0.4
Miscellaneous	5	1.9	1.0
Total	261	100	
Common Causes	216		42.4
Special Hazard Causes	261		52.2
Incendiary	13		2.5
Exposure	20		3.9
Total Known Causes	510		100
Unknown Causes	122		
Total	632		

Details.

Common Hazards.

Lighting 20
- Caused by kerosene oil lamps 3
- Workman attempted to locate a gas leak with lighted match; he found the leak 1
- Leaking gas ignited by watchman's lantern 1
- Leaking gas ignited by open light 2
- Boy was lighting a gas jet with a piece of burning string and ignited some oily material 1
- Curtain was blown into open gas jet 1
- Dust on belt ignited by open gas jet 1
- Gas jet lighted too near inflammable vapors 1
- Inflammable material in contact with gas jet 3
- Electric light transformer on outside of building became overheated 1
- Defective electric wiring 1
- Defective electric flexible cord 1
- Electric lamp in contact with combustible material 2
- Employee used match for illumination to see if a can was full of oil proofing material. Contents of barrel became ignited 1

Heating 7
- Steam pipes in contact with combustible material 3
- Steam pipes through side of building ignited woodwork 1

Accumulation of dust, etc., inside of blower system became ignited..... 1
Heater became overheated..... 1
Stove ignited combustible material..... 1
Power 24
Transmission 18
Friction at loose wood pulley.....12
Overheated bearings..... 5
Hot bearings on rope drive shafting..... 1
Electric Power..... 5
Short circuit in fan motor.
Spark from electric motor ignited burlap covering.
Motor started at full speed and was burned out.
Overheated wires at motor.
Governor belt broke, allowing engine to race, which caused dynamo to overcharge the wires. Wire burned out and a spark dropped into rubber cement.
Defective Gas Engine..... 1
Boiler and Fuel..... 26
Sparks from chimney or stack ignited roof of detached shed... 9
Careless disposal of hot ashes..... 3
Spontaneous ignition of soft coal..... 3
Sparks ignited refuse or fuel in front of boiler..... 3
Boiler explosions..... 2
Woodwork near boiler ignited..... 2
Blow-off pipe gave way, and fire blown from fire box into combustible material..... 1
Hot poker hung against woodwork..... 1
Dust over boiler ignited..... 1
Box on top of boiler ignited..... 1
Chimneys and Flues..... 1
Soot in flue which passed through dry room became ignited.
Sparks 4
Sparks from exposing chimneys..... 2
Sparks from locomotives..... 2
Fourth of July..... 2
Skyrocket landed on roof.
Skyrocket came through window.
Lightning caused fires..... 8
Smoking 34
Lighted cigars or cigarettes thrown into combustible material.. 9
Careless disposal of matches..... 7
Smoking in presence of inflammable volatiles..... 4
Cigarettes or butts thrown into blower system..... 4
Sparks from pipes, etc..... 2
Hot pipe or matches in workmen's clothes..... 1
Miscellaneous carelessness 7

Matches 11
- Careless use for lighting purposes 3
- Ignited in workmen's clothes 2
- Workmen stepped on snap matches 2
- Shoe rack containing shoes, whose channels had been recently cemented, was ignited by a snap match caused by rack being rolled over it 1
- Lighted match used for illumination 1
- Lighted match thrown onto inflammable material 1
- Spark from match ignited cotton flannel shoe linings 1

Rubbish and Sweepings 45
- Under benches, in wooden boxes and barrels, etc.

Spontaneous Ignition 22
- Oily material 19
  - Oily waste 10
  - Oily cleaning rags 2
  - Oil-soaked rags for oiling floor 1
  - Miscellaneous, not enumerated 6
- Sawdust in a wooden box 1
- Miscellaneous 1
- Workmen's clothing 1

Careless Use of Volatiles 4
- Benzine emptied into closet, carelessly ignited.
- Kerosene used by boy for cleaning machinery, carelessly ignited.
- Painters left open pail of benzine used for cleaning brushes and the same became carelessly ignited.
- Benzine used by watchman to clean his clothes became ignited.

Carelessness of Employees 3
- Gas stove carelessly used to warm coffee or prepare a lunch.

Electric Currents 5
- Thermostat wires crossed with electric light wires 2
- Thermostat wires crossed with high tension wires 2
- Thermostat wires fell onto trolley during heavy storm 1

Special Hazards.

Cementing 65
- Presence of open flames near rubber cement 31
  - Open gas jet ignited naphtha vapors 17
  - Kerosene oil lantern ignited naphtha vapors 5
  - Kerosene oil lamp ignited naphtha vapors 3
  - Gas stove ignited naphtha vapors 3
  - Lighted wax paper ignited naphtha vapors 2
  - Dish of cement held too near open flame of embossing machine 1

Careless use of matches near rubber cement.....20
Lighted match ignited naphtha vapors 8
Lighted match dropped or heads flew off 8
Matches stepped on and vapors ignited 4
Presence of electric lights 2
Spark caused by screwing in bulb.
Spark from broken bulb.
Naphtha vapors ignited by smoking..... 1
Naphtha vapors ignited from spark caused by striking nails.... 2
Naphtha vapors ignited by spark from knife used to spread cork filler, striking can..... 1
Naphtha vapors ignited by static electricity or sparks caused in some manner not enumerated..... 8
Finishing 51
Cleaning.....16
Naphtha used for cleaning ignited while lighting up..... 5
Naphtha ignited by gas stove..... 3
Naphtha ignited by matches or smoking 2
Naphtha ignited by kerosene oil stove 1
Bottle of naphtha upset..... 1
Naphtha carelessly ignited, manner not enumerated 4
Waxing.....12
Wax boiled over or ignited on gas or kerosene oil stoves.. 9
Stoves left burning 3
Treeing..... 8
Careless use of matches in lighting burner at treeing irons 3
Electric irons used; cross circuits formed in some manner 2
Naphtha vapor ignited by static electricity while pouring naphtha from can to treer's can..... 1
Treeing iron stove ignited a polishing ball..... 1
Treer's compound ignited..... 1
Kit Tools 7
Gas left burning inside of kit tools heater.
Rubber tubing to gas heater burned off.
Careless disposal of match after lighting gas heater.
Kerosene oil kit tools stove upset.
Kerosene oil kit tools stove filled with naphtha by mistake.
In lighting a kit tool stove, naphtha from a leaky safety can became ignited.
Alcohol kit tool lamp set fire to pile of nearby papers.
Polishing 5
Friction ignited gasolene used for cleaning polishing wheels 2
Dust ignited by open gas jet..... 1
Wax lint from polishing wheels ignited on steam pipe.... 1
Spontaneous ignition of dust on dust pipe..... 1

Spontaneous Ignition 2
Oily polishing wheel.
Oily cleaning rags.
Edge Setter 1
Gas flame left burning and ignited belt and pulley.
Cutting Board Scrapings 28
Left on benches, under benches, in boxes, etc., ignited spontaneously.
Making 23
Stitching Machines 13
Gas left burning, or boiling over of wax from wax cups on machines, kind not enumerated 8
Boiling over of wax cups on Goodyear welt machines 3
Boiling over of wax cups on McKay machines 2
Ignition of wood alcohol or alcoline lamps which were filled while burning 3
Static electric sparks caused fire 2
Gas flame under wax pot on seamer turned too high and ignited table 1
Wind blew curtain into flame on stitching machine 1
Gas jet ignited thread 1
Employee cleaning stitching machine with oily waste set fire to waste from gas jet on machine 1
Spontaneous ignition of accumulation on Goodyear welt machine 1
Buffing 18
Ignition in blower pipes 9
Buffing dust in room ignited by proximity to steam pipes, etc. 4
Spontaneous ignition in dust box or vault 3
Spontaneous ignition of tip scourings 1
Buffing dust escaped from vent pipe on roof and ignited.
Waste Chute 16
Spontaneous ignition and in some cases due to careless smoking.
Naphtha Black 12
Employees stepped on matches and ignited naphtha black 3
Lighted matches ignited vapor from naphtha black 2
Open gas flame ignited vapors 3
Spark from electric light ignited vapors 1
Spark caused by iron hoop on barrel striking concrete floor ignited vapors 1
Naphtha vapors ignited, no details 2
Cement House Fires 11
Match lighted while drawing cement 5
Match stepped on while drawing cement 3
Employee entered cement house smoking 1
Cause not given 2

Volatiles and Combustibles 10
- Naphtha fumes in laboratory ignited by gas stove.
- Naphtha vapors in stitching room ignited by open light.
- Gasolene poured into sink ignited by cigarette or match.
- Man stepped on match while boy was pouring gasolene out of can.
- Can of marking ink thinned with alcohol brought into too close proximity with open gas jet.
- Bag of naphtha "bleached" leather stock insufficiently dried filled room with naphtha vapor, which was ignited by match while gas jet was being lighted.
- Explosion of carbon bisulphide in laboratory.
- Employee struck match to see while drawing alcohol from a barrel.
- Can of phosphorus in waste rusted out, allowing phosphorus to become dry.
- Ignition of "stifferene" by open flame.

Water proofing 5
- Tank of viscol ignited by match 2
- Vapors from tank of viscol ignited by open lights 2
- Paraffine dip tank overheated 1

Heating Compounds, Stains, etc. 4
- Materials boiled over 3
- Compound ignited from gas stove while pouring 1

Ironing 3
- Electric heated pressing irons left with current turned on 2
- Kerosene oil stove used to heat flat-iron exploded 1

Pounding Machine 3
- Sparks from emery wheel.

Singeing Machine 3
- Singeing lamp too full and flame ignited oil on outside and on table.
- Gas flame used for singeing ignited some shoe tips which had been dipped in naphtha dye.
- Naphtha fumes ignited by alcohol lamp used in singeing tips.

Stamping Machine 2
- Heat from machine ignited naphtha on shoe.
- Flame from machine ignited contents of gasolene tank.

Scouring Machine 2
- Employee scratched match on sandpaper wheel while it was in motion.
- Spontaneous ignition of dust from machine.

Miscellaneous 5
- Leather stock ignited spontaneously or otherwise 3
- Spark from match ignited naphtha-saturated waste in pounding room 1
- Sample package of color became broken and ignited oil-soaked sawdust 1

2. MISCELLANEOUS STATISTICS.

Analysis of Losses.

Fires Where Sprinklers Operated.

	Common Causes.		Special Causes.		Unknown Incendiary Exposure.		Total No. of Fires.	
	No. of Fires.	Per Cent.	No. of Fires.	Per Cent.	No. of Fires.	Per Cent.	No. of Fires.	Per Cent.
No Claim	26	20	42	29	10	11	78	21
Small Loss	89	71	92	63	67	71	248	68
Large Loss	11	9	11	8	17	18	39	11
Total	126		145		94		365	

Relation Between Effect of Sprinklers and Losses.

	Extinguished.		Held in Check.		Unsatisfactory.	
	No. of Fires.	Per cent of Extinguished.	No. of Fires.	Per cent of Held in Check.	No. of Fires.	Per cent of Unsatisfactory.
No Claim	73	26	5	7	..	..
Small Loss	191	68	56	78	1	8
Large Loss	17	6	11	15	11	92
Total	281		72		12	

Relation Between Large Losses and Causes.

	Sprinklers Operated Satisfactorily.		Sprinklers Operated Unsatisfactorily.		Total Large Loss.	
	No. of Fires.	Per Cent.	No. of Fires.	Per Cent.	No. of Fires.	Per Cent.
Common Cause	8	36	3	33	11	35.5
Special Hazard	10	46	1	11	11	35.5
Exposure	4	18	5	56	9	*29.0
	22		9		31	
Unknown (Common or Special Hazard)	6		2		8	
Total	28		11		39	

Fires Where Sprinklers Were Not Affected.

	Common Causes.		Special Causes.		Unknown Incendiary Exposure.		Total No. of Fires.	
	No. of Fires.	Per Cent.	No. of Fires.	Per Cent.	No. of Fires.	Per Cent.	No. of Fires.	Per Cent.
No Claim	19	28	24	24	4	17	47	24.5
Small Loss	48	72	76	76	19	79	143	75.0
Large Loss	..	..	..	..	1	4	1	0.5
Total	67		100		24		191	

* Exposure, 23 per cent of all large loss fires, including the large loss fires due to unknown causes.

Fires in Unsprinklered Risks.

	Common Causes.		Special Causes.		Unknown Incendiary. Exposure		Total No of Fires.	
	No. of Fires.	Per Cent.	No. of Fires.	Per Cent.	No. of Fires.	Per Cent.	No. of Fires.	Per Cent.
No Claim	3	13	2	13	..	..	5	6.5
Small Loss	15	65	9	56	12	33	36	47.5
Large Loss	5	22	5	31	25	67	35	46.0
Total	23		16		37		76	

Twenty-eight per cent of these fires occurred in unsprinklered portions of sprinklered plants, or twenty-one cases.

All Shoe Factory Fires.

	Common Causes.		Special Causes.		Unknown Incendiary Exposure.		Total No. of Fires.	
	No. of Fires.	Per Cent.	No. of Fires.	Per Cent.	No. of Fires.	Per Cent.	No. of Fires.	Per Cent.
No Claim	48	22	68	26	14	9	130	21
Small Loss	152	71	177	68	98	63	427	67
Large Loss	16	7	16	6	43	28	75	12
Total	216		261		155		632	

Water Losses in Sprinklered Factories.

In ninety-eight cases, or about twenty-seven per cent of the fires, the principal loss was mentioned as specifically due to water damage.

Brockton and Lynn Contrasted.

Brockton, Mass., mostly individual plants. Total number of fires where sprinklers operated, 49: no claim, 10 per cent; small loss, 78 per cent; large loss, 12 per cent.

Lynn, Mass., mostly tenant buildings. Total number of fires where sprinklers operated, 92: no claim, 10 per cent; small loss, 82 per cent; large loss, 8 per cent.

Individual and Tenant Plants.

There were 100 fires where sprinklers operated that clearly occurred in individual plants and 128 fires that occurred in tenant factories.

Of the individual plants, 18 per cent of the fires resulted in no claim, 78 per cent in moderate loss, and 4 per cent resulted in a large loss.

Of the tenant factories, 9 per cent of the fires resulted in no claim, 84 per cent in moderate loss and 7 per cent resulted in a large loss.

Of the twelve sprinkler failures, eleven occurred in individual plants.

Protection Other Than Automatic Sprinklers.

Outside hose streams, irrespective of public chemical streams, were reported as used in 97 cases where the sprinklers operated.

Inside protection of some kind, irrespective of the automatic sprinklers, was reported as used in 99 cases where the sprinklers operated, and in 10 cases, two kinds of protection were mentioned. In all, the various kinds of inside protection reported as used were as follows: water parts, 34; chemical extinguishers, 66; hand hose, 6; standpipes, 4.

Protection Where no Sprinklers Operated.

In 191 cases the heat was either not sufficient to operate the sprinklers or available means at hand for extinguishing fires were used so promptly that the sprinklers were given no opportunity to operate. In these cases the following agencies were used: water pails, 70; chemical extinguishers, 58; smothered with wet burlap, blankets, etc., 36; fire department used hose streams, etc., 27; fire department used chemical engine, 12; hand hose, 5; standpipe, 6; dry powder extinguishers, 6; sand pails, 3; open sprinklers, 3; fire stamped out, 3; fire went out, 3; cause removed, 3; lightning, no fire, 3; no data, 9. Two agencies used in 46 cases and three agencies used in seven cases.

Amount of Water Used by Automatic Sprinklers.

In sixty-five cases where the sprinklers extinguished the fire, the approximate amount of water used was reported. The average amount of water used was 1,500 gallons per fire, and the actual amounts varied from 60 to 10,000 gallons. The following table shows the number of fires extinguished by the use of various amounts of water. It will be observed that more than two-thirds of the fires were extinguished by the use of 1,500 gallons or less of water.

10,000 gallons	1 fire	1,500 gallons	3 fires
5,000 "	2 fires	1,200 "	1 fire
4,000 "	1 fire	1,000 "	12 fires
3,000 "	3 fires	800 "	3 "
2,800 "	1 fire	600 "	4 "
2,500 "	2 fires	500 "	12 "
2,000 "	6 "	400 "	3 "
1,800 "	2 "	300 "	1 fire
1,600 "	1 fire	200 "	5 fires
		100 " or less	2 "

3. ROOMS IN WHICH FIRE OCCURRED.

	Common Causes.		Special Hazards.		Unknown Incendiary Exposure.		Total No. of Fires.	
	No. of Fires.	Per Cent.	No. of Fires.	Per Cent.	No. of Fires.	Per Cent.	No. of Fires.	Per Cent.
Above First Floor								
Data not given	16	7.7	1	0.4	10	7.2	27	4.7
Attic or Top Floor	3	1.5	7	2.7	5	3.6	15	2.5
Awning	1	0.5	..	..	1	0.7	2	0.3
Basement	3	1.5	3	1.2	6	4.3	12	2.0
Blower Pipe	3	1.5	3	1.2	..	..	6	1.0

	Common Causes.		Special Hazards.		Unknown Incendiary Exposure.		Total No. of Fires.	
	No. of Fires.	Per Cent.	No. of Fires.	Per Cent.	No. of Fires.	Per Cent.	No. of Fires.	Per Cent.
Boiler Room . .	25	12.0	5	1.9	5	3.6	35	5.8
Cement House .	4	1.9	13	5.1	..	..	17	2.8
Cementing Room .	..	..	2	0.8	..	..	2	0.3
Closet	2	1.0	..	..	..	..	2	0.3
Cutting Room .	13	6.3	23	9.0	18	12.9	54	9.0
Dry Room . . .	1	0.5	..	..	1	1.4	2	0.3
Dust or Waste Bin or Vault . . .	1	0.5	4	1.6	..	..	5	0.8
Engine Room or Power	3	1.5	1	0.4	3	2.1	7	1.2
Exposure. Location indeterminate	..	..	..	..	12	8.6	12	2.0
Finishing Room .	11	5.3	59	23.2	7	5.0	77	12.8
Heel, Counter or Box Toe Mfg. .	3	1.5	1	0.4	..	..	4	0.7
Laboratory . . .	..	..	2	0.8	..	..	2	0.3
Lasting Room . .	3	1.5	2	0.8	..	..	5	0.8
Making (Bottoming, Stitching, Welting, etc.) .	34	16.4	52	20.4	21	15.1	107	17 8
Miscellaneous . .	12	5.8	9	3.5	11	7.9	32	5.3
Office	5	2.4	2	0.8	1	0.7	8	1.3
Outside	4	1.9	3	1.2	3	2.1	10	1.7
Packing and Shipping Room . .	7	3.3	2	0.8	2	1.4	11	1.8
Paper Box Mfg. .	..	..	..	..	2	1.4	2	0.3
Roof	12	5.8	1	0.4	2	1.4	15	2.5
Sole Leather Room	6	2.9	10	3.9	3	2.1	19	3.2
Stain or Polish Mixing . . .	..	..	2	0.8	1	0.7	3	0.5
Stitching Upper Leather . . .	11	5.3	27	10.6	7	5.0	45	7.5
Storage and Non-Manufacturing .	24	11.6	6	2.3	18	12.9	48	8.0
Waste Chute . .	..	..	15	5.9	..	..	15	2.5
Total with data given	207		255		139		601	
No data	9		6		16		31	
Totals . .	216		261		155		632	

4. DAY OR NIGHT FIRES. (Day Fires 6 a. m. to 6 p. m.)

	Common Causes.		Special Hazards.		Unknown Incendiary Exposure.		Total No. of Fires.	
	No. of Fires.	Per Cent.	No. of Fires.	Per Cent.	No. of Fires.	Per Cent.	No. of Fires.	Per Cent.
Day	109	51	188	72	46	31	343	55
Night	105	49	73	28	102	69	280	45
Total with data given	214		261		148		623	
No data	2		..		7		9	
Total	216		261		155		632	

5. PLANT IN OPERATION.

	Common Causes.		Special Hazards.		Unknown Incendiary Exposure.		Total No. of Fires.	
	No. of Fires.	Per Cent.	No. of Fires.	Per Cent.	No. of Fires.	Per Cent.	No. of Fires.	Per Cent.
Plant in operation	89	42	166	64	27	18	282	45
Plant not in operation	125	58	95	36	121	82	341	55
Total with data given	214		261		148		623	
No data	2		..		7		9	
Total	216		261		155		632	

6. HOW DISCOVERED.

	Common Causes.		Special Hazards.		Unknown Incendiary Exposure.		Total No. of Fires.	
	No. of Fires.	Per Cent.	No. of Fires.	Per Cent.	No. of Fires.	Per Cent.	No. of Fires.	Per Cent.
Employee	78	37	169	67.0	26	19.0	273	46
Watchman	16	8	19	7.5	9	6.5	44	7
Thermostat	55	27	31	12.0	39	28.0	125	21
Sprinkler Alarm	16	8	17	6.5	13	9.5	46	7
Outsider	42	20	18	7.0	49	36.0	109	18
Supervisory	..	..	..	..	1	..	1	..
Total with data given	207		254		137		598	
No data	9		7		18		34	
Total	216		261		155		632	

SPRINKLER FIRE RECORD.

7. EFFECT OF SPRINKLERS.

	No. of Fires.	Per Cent of Whole.
Extinguished or practically extinguished fire	281	77
Held fire in check	72	20
Unsatisfactory	12	3
Total	365	
No claim	78	22
Small loss	248	68
Large loss	39	10
Total	365	
No heads opened	191	

8. DETAILS OF UNSATISFACTORY SPRINKLER FIRES.

2154. Fire occurred at about midnight. It was said to have been discovered by a man across street in a printing office. Fire was then well underway in top story near front of building. He pulled in alarm box at 12.55 and the local call department responded. Steamer and hose house in same yard as factory and several members live near by so that not much time was lost. Steamer pumped from river close by. Before department got to work the factory was doomed, as fire had spread through upper floors and the department had their hands full saving nearby property. The factory burned to the ground, nothing left standing but boiler house walls. Ruins were burning all the next day. Box shop at rear, brick fire department house, three dwellings at rear of same, group of frame buildings east of factory, frame store and dwelling one hundred feet or more west of factory, also six or eight wood stores and dwellings across street were all totally consumed.

Construction. Factory was a large frame building of about 15,000 square feet ground area, all one fire section except fair cut-off to a one-story brick boiler and engine house. Basement and five stories of good open plank and timber construction. Main stairway in front of building, open in a hallway, latter being shut off on each floor by a light wood partition. Another stairway at rear shut off each floor. Elevators had automatic traps. It was substantially built and would have been classed as a good open mill constructed frame shoe factory.

Sprinkler Equipment. Building was equipped throughout with a good sprinkler equipment, wet system, Grinnell glass disc heads. Spacing standard ten feet in eight-foot bays and old standard pipe sizes. Arrangement of risers and feed mains satisfactory.

Primary supply from 11,000 gallon gravity tank in top of front stair tower, bottom eleven feet above top line of sprinklers giving about ten pounds pressure. Second supply from 750 gallon steam pump well located in cut-off boiler and engine house. Pump draughted from cistern of about 20,000 gallons capacity. Steam at all times. There was a steamer connection at front of factory, but it was not used. The tank supply fed to boiler room, where it connected with the pump supply, and from that point there was a six-inch feed to sprinkler system with a Grinnell angle alarm check (not used as an alarm).

Alarm Service. Plant was supposed to have good watchman and clock service, but the regular watchman left on night previous to fire. He was to have stopped work next week and had so notified owners, but later changed his plans. The superintendent stated that when he found his regular man was to leave, he made arrangements to hire another regular watchman, but as the latter could not come at once he found a local man who agreed to watch until he could get the permanent man. The next day the superintendent found no one had watched the shop the previous night, and made a further endeavor to get the other man to come at once, but was unsuccessful, and the shop was without a watchman the night of fire. As it turned out it was a grave error to leave factory alone, and it is altogether probable that shop would not have burned had there been a watchman.

Cause of Fire. Fire apparently started in packing room on top floor near front stairway. This top floor was without partition except the hall enclosure and was one large open area. When discovered fire was well underway. The fire was believed to have been the work of an incendiary.

Action During Fire. The factory engineer stated that he arrived inside of ten minutes and by that time the upper floors and front of factory were well on fire. Just how bad the fire was at this time is hard to determine. The engineer evidently lost his head, as he had no trouble in going into boiler room and yet he made no attempt to start the fire pump. He said steam was up and the only reason pump was not run was because he thought it would do no good. The fire had not at that time reached the lower floors, as a short time after this the superintendent arrived and went up part way to office on second floor. He was afraid to go farther and went back through boiler room.

Conclusions. Chief defects were lack of automatic supply of heavy pressure and insufficient water supply for pump.

Primary cause of loss was lack of watchman. This was something which could not have been foreseen and which was out of the ordinary. Had there been a sprinkler alarm valve it is quite probable that factory would not have burned. Watchman service should in every case be supplemented by a sprinkler alarm, for otherwise fire may not be discovered for a considerable length of time. Furthermore, many factories have no regular watchman during the day, Sundays and holidays, and there are liable to be other times, as in this case, where watchman is off duty temporarily.

If pump had been automatic the heavy pressure might have been sufficient to entirely extinguish fire.

Had the pump been started as soon as engineer arrived the fire might have been held in check, but this also is an open question. The fire demonstrated that it is quite possible for a skilled engineer to lose his head.

Total loss, building, $18,000; contents, $149,500.

Summary: No alarm service.

3556. March 20, 1905. R. B. Grover & Co., Brockton, Mass. At about 8 a. m. the boiler located in the brick addition adjoining main shop exploded. It was stated that this boiler had been but little used for several years, but had been inspected in December. It was used as an emergency boiler and was started up the day before the explosion. It was stated that there was about one hundred pounds steam pressure at the time of the explosion.

The boiler itself was blown a distance of some 200 feet, passing directly through a dwelling house just north of rear wing of factory and landing in the next dwelling beyond. At the same time the main factory adjoining boiler house was practically demolished by the force of the explosion.

One of the firemen in the fire department house, which was in the same block, stated he saw the sprinkler tank on the rear wing fall immediately after the explosion. A man on the third floor of the main building stated that the floors of the section where he was, fell, and he crawled out of a hole on the first floor.

The extent of the damage done by the explosion could not be estimated exactly, but was about ten per cent of the total loss.

Fire ensued almost immediately and the sprinkler system proved of no value on account of the breaking of main pipes. A main six-inch pipe ran through the basement close to the boiler house, feeding sprinklers in rear wing and a four-inch tank pipe from the tank on the rear wing ran close to it. Both of these were undoubtedly broken by the explosion. Fire spread rapidly and the entire plant was soon in flames. In spite of the quick work of the fire department, the flames spread to buildings across the street, destroying a three-story frame block and stores at rear of same. A dwelling just north of factory was entirely destroyed and those nearby were very considerably damaged.

About fifty persons lost their lives. There were about 200 in the factory at the time of the explosion and many of these were badly injured. Total property loss, $254,675.

Summary: Sprinkler system crippled by boiler explosion.

3615. April 14, 1905. At 1.35 a. m. the town watchman heard a slight explosion and looking toward the shoe factory saw a light in the boiler room. He ran to factory and seeing there was a fire pulled the town fire alarm. When department arrived the boiler room was all on fire, and when it was attempted to put streams on, it was found that there was no pressure. Factory engineer was meanwhile trying to get the rotary pump into service but was driven back by the fire after partly opening the gates.

The water in pond was so low, however, that there was not power enough to drive pump even if the gates had been open. Sprinklers had to depend on a 5,400 gallon gravity tank. The sprinklers in boiler room were all high test, and the only one that could be found failed to open. Sprinklers in small room adjoining boiler house were shut off.

Fire spread to neighboring buildings, and before it was checked had wiped out the center of the town, including a vacant shoe factory across the river. In all forty-seven buildings were consumed.

A careful investigation developed the fact that there was no water of account in tank or sprinkler system.

Without doubt the thermostats did not operate. They were the old ether tube type, and the system had always been more or less out of order.

Pump was not in good condition. An attempt was made to start pump on night of fire, but although three men tried to turn outside wheel and lift the gate in order to start water wheel, they could only lift it an inch.

Summary: Deficient water supplies and outside protection.

3748. Three story frame factory, mansard roof; exposed by frame shoe factory, with one and two story addition ten feet distant, and main three and four story factory sixty feet distant. Factory equipped with Walworth sprinklers, wet system, supplied by town water of fifty pounds pressure, second supply small rotary pump. Fire started at 2.30 p. m. at the four-story exposing factory and spread with great rapidity. Sprinklered factory had a system of open sprinklers on mansard roof which held the fire in check for a while, but later on, owing to the severe heat, the wood factory caught fire and was totally destroyed. It is stated that factory burned very slowly, owing to the action of the automatic sprinklers. It was understood that the protection against exposure was inadequate, and owing to the location of the river, it was impossible to fight fire except from street side.

Summary: A frame factory, heavily exposed by a frame factory, burned from exposure.

3747. Four-story frame factory heavily exposed by a large frame car works. Factory was equipped with Walworth sprinklers, wet system, supplied by waterworks, forty-five pounds. Small gravity tank five feet above and a five hundred gallon steam pump draughting from five thousand gallon cistern. There was a line of open sprinklers on the cornice, these sprinklers having same water supply as those inside. Pump was used to supply a hose stream while the exposure was burning and the cistern was soon exhausted. Tank supply too small to be of value. As the steamers arrived the city pressure was reduced so that there was no water for open sprinklers or the automatic sprinklers in the upper floors. Factory caught fire all along the exposed side and burned very rapidly. The exposing fire made excessive heat and both buildings were doomed shortly after the department arrived.

Summary: Frame factory burned from a heavy exposure, weak waterworks.

3746. Fire broke out in the second story in the lasting room about 6.10 p. m. It was first seen by the people in the dwelling nearby and an alarm was immediately given. The town people were soon rendering what assistance they could. The building was three-story, wood, of light joisted construction, sheathing on studding, not cut off at floors, and occupied as a shoe shop. The fire is supposed to have been caused by the wax cup on one of the McKay stitching machines boiling over; these cups were heated by an alcholine lamp which was probably left lighted by the workman when he left at 6 p. m., and it set fire to the wax as it boiled over. The fire must have worked its way along to the walls and when once between the weather boards and sheathing it probably gained great headway. The following facts account for the fire having got beyond control of the sprinklers. The general construction of the building and the poor sprinkler equipment which was below standard in spacing, pipe sizes and supplies. The spacing was ten feet across joist and the pipe sizes as follows: twenty heads on two-inch twice and sixteen heads on one and one-half inch twice on each floor. The primary supply was from a gravity tank of three thousand gallons capacity, fourteen feet above top sprinklers, one eighth of which could be used for factory service; and the secondary supply from a small Deane single steam pump located in the engine room. This pump also fed two double hydrants in the road. The sprinklers were of Walworth pattern installed in 1887 and 1890 and were on the wet system. These are said to have operated and worked as long as the water lasted. The pump was of very little value, it discharging only a small amount of water through the hose which was connected to the hydrants.

Summary: Frame factory. Poorly constructed with concealed spaces. Poor water supplies.

5489. West Lynn Conflagration, December 6, 1906. Boiler located in one-story brick boiler house adjoining. Explosion wrecked boiler house and part of the side wall of the four-story frame shoe factory and broke large sprinkler feed pipe, thereby crippling the system. The factory caught fire shortly after, and before any hose streams could be used by the fire department the fire was beyond control. This fire also destroyed two other sprinklered frame shoe factories (see below) and damaged a fourth. Boiler was of the lap seam, horizontal, tubular return pattern. The cause of the explosion was doubtful. There was considerable wind at the time of fire and the fire department could do nothing more than attempt to save adjoining property.

The following conclusions appeared in the inspector's report: (1) That the factory care and business management at the factory were not such as would reduce to a minimum the possibility of an accident of this kind. (2) That the water supply in this locality was not adequate enough to cope with a disaster of this kind and that waterworks valves on sprinkler service should be installed in some sort of a pit so that they may be readily accessible to firemen. (3) That city gas companies be compelled to provide outside shut-off valves readily accessible on all gas

S-5489.

General view looking west, showing ruins of engine house and exploded boiler.

S-5489.

Looking east from Commercial Street.

mains entering buildings. The rapid spread of the fire was undoubtedly due to the fact that the gas main in building was broken and that gas diffused through the premises. (4) That outside sprinkler protection against exposing sprinklered buildings is of small service and sometimes is a positive detriment to the fighting of fire unless there is provided an adequate supply independent from town water or a steamer connection. (5) That in laying out all main risers and main sprinkler connections, sprinklers, tanks and drop from tanks, due cognizance be taken of the location of boiler house so that all such piping may be kept the farthest possible from such sources of danger. (6) Steamer connections to automatic sprinklers should be specified on city buildings where pressure is light and street mains not large. Had there been such a connection on the westerly building it might have been saved; possibly a large tank as second supply would have served the same purpose.

Summary: Boiler explosion.

5490. Four-story frame shoe factory burned from the exposure of the factory noted above. The boiler was located between the two factories and somewhat damaged this factory also, but no fire started in this factory and it would not have burned but for the exposure. It is quite likely that some of the small pipes in the factory were damaged by the explosion and the sprinkler system could not have been much of any service, due to the pipes breaking in the exposing factory, thereby greatly reducing the pressure of the street main. Street main was six-inch and primary pressure about sixty pounds.

Summary: Exposure.

5491. Four-story frame shoe factory burned from exposure of the two factories noted above. This factory was about twenty-five feet distant from the last mentioned and there was a system of eave sprinklers as a protection against exposure. These outside sprinklers were fed by city water only, and before fire reached this factory the pressure was so far reduced that they were of no value. Factory was totally destroyed.

Summary: Exposure.

5856. Shoe Factory. Fire started in third story of frame boarding house and store about twenty feet from frame sprinklered shoe factory. The outside protection was poor and the exposure got beyond the control of the fire department and attacked shoe factory, burning off the two upper floors. Factory was equipped with Grinnell glass disc sprinklers, old standard spacing and pipe sizes, wet system, supplied by waterworks fifty to seventy pounds pressure and gravity tank. Hose streams reduced the street pressure, and owing to the large number of sprinklers which were opened, the system was overtaxed. Building had a wood box cornice and under the cornice were Grinnell shovel pattern open sprinklers. No one thought of these sprinklers, and they were not used.

Summary: Defective equipment.

8434. At 11.47 p. m. a policeman saw a light in the corner of the third floor of the main building and rang in the fire alarm box at the

corner. Meanwhile the fire had spread throughout the whole end of the building. The fire apparently started from an unknown cause in or near a metal waste barrel which stood in the easterly corner of third floor near elevator.

At 11.49 Hose No. 9 reached the fire and at once directed two streams in the corner of the building where the elevator is located, devoting their energies to keeping the fire from spreading down the elevator to the second floor where excessive quantities of paper tubes and paper tube waste were stored. These men did not notice whether the sprinklers were in operation or not. Firemen from other stations reached the fire shortly afterwards and carried lines in through the other end and sides, and they stated positively that the sprinklers were not in operation on the third floor when they entered the building. The firemen did very good work and the dismissal was given at 2 a. m. The water supply was adequate and no defect was noted except the breaking of the stem of a three-way hydrant.

The thermostat system had recently undergone extensive repairs, and a Wall testing device had been installed. The thermostats were tested the day of the fire and showed no defect at the fire station. The thermostats did not ring at the fire station at the time of the fire, and patrolman giving alarm states that bell was not ringing on front of factory, but by the time the nearby hose company had reached the factory, probably three to five minutes after fire started, the thermostat bell on the front of the factory was ringing. Thermostats were the Watkins improved type (1899), unapproved spacing, and it is not known why they failed to operate promptly.

One of the members of the fire department, by direction of the chief, at about 12.15 a. m., May 16, closed the main gate valve below the alarm valve on the city connection and the valve under the tank controlling the tank supply. These two valves were of the indicator pattern, and the brightness of the stem under the indicator follower in the "open" position, showed that they were usually open. The valve at the foot of the main riser on the first floor and the valve controlling the second floor, and the two valves controlling the third, were not of the indicator pattern, and there was no evidence to show in what condition they had been kept. The cold weather valve, controlling the sprinklers in the tower, was closed at the time of the fire (proved by the fact that while the struts had melted from the sprinkler heads, the glass buttons had not left their seats). The superintendent of the waterworks states that he examined the gate valve in street in connection pipe to sprinklers and found this open, with no evidence of its having been closed.

The sprinkler pipes in the southeast half of the third floor showed that they became red-hot during the fire; the sprinkler heads on these pipes showed evidence of great heat, these two facts indicating that no water was flowing through the pipes at the time of the fire.

After the fire there were three feet of water in the tank, and the appearance of the tank did not seem to show that the water had been above

that level for some time. Condition of other valves in the building, particularly the one at the base of the main riser, and the two valves controlling the third floor was questionable. It appears to have been doubtful whether the two latter were open, and this may have been the reason the sprinklers failed to control the fire.

Spread of fire to second floor was largely prevented by elevator enclosure (seven-eighths inch wood), and enclosed stairway (seven-eighths inch wood), both very near origin of fire. Prominent defects brought out by fire were: lack of proper supervisory system for sprinkler equipment; deficient thermostat system; the former defect was undoubtedly responsible for the large damage done.

Sprinklers installed in 1897; ninety-five in room, all opened on third floor, one in stairway second to third floor at southeast end, and several in tower. Pipes installed in 1897, pipe sizes 1896 standard. Spacing and arrangement of sprinklers, mill construction, ten feet apart in ten-foot bays; no obstruction to distribution. Wet system where fire occurred. Primary water supply, city waterworks, fifty-four pounds pressure.

Fire was very well managed by public fire department. Practically total loss on third floor, heavy water damage only on first and second floors. Loss, $50,000.

Summary: Defective sprinkler equipment. Defective automatic fire alarm.

12849. Fire occurred in the south end of the top floor of factory in part used for storage of lasts in racks. It was discovered by the watchman of an adjoining sprinklered building and when found was breaking through the roof. It appeared to have caught on, or just under, the roof, breaking through it and also dropping down to a rack of shoe lasts beneath. Watchman of this factory had made his round half an hour before, but saw no evidences of fire. The fire department was called and watchman attacked the blaze with pails and it was quickly extinguished. The principal loss was on damaged lasts, sixty-six pair being spoiled, loss $95.04.

The interesting feature of this fire was the failure of a Grinnell "D" head to operate. One located directly above fire was fused, but the head failed to open. In this case fortunately it did no harm and probably reduced the water damage, but in another case it might have caused a total loss of mill.

Summary: Defective type of sprinklers.

9. DETAILS OF LARGE LOSS SPRINKLER FIRES. (Where sprinkler control was satisfactory.)

856. During changes a glycerine pot regulator on city gas connection had been replaced, but workmen had forgotten to put the required amount of glycerine into the regulator. The odor of gas was perceptible, and an employee lighted a match and held it near the top of regulator. A flash of fire circled about the ceiling for a radius of about fifteen feet, burned up a curtain and singed pieces of string hanging from ceiling. One Grinnell

metal disc sprinkler came within the radius of the heat, and the solder was all fused except in one place about as large as the head of a pin. This was not discovered at the time. It apparently gave way shortly after the factory closed at night. Water was discovered by an outsider about ten o'clock at night flowing out of the building. There was no alarm valve on sprinkler system. Water loss of $7,800 resulted.

9481. Building was forty-eight feet wide, of open joist construction. Fire occurred center of second floor, caused by the ignition of matches in an employee's jumper which was thrown on the floor. The heat spread both ways between two floor joists, fusing two sprinklers near the center and one each side of the building, quickly extinguishing the fire but causing a large water loss. The sprinklers operated under a pressure of eighty pounds. Loss on building, $167; water loss on contents, $7,273.

9619. This was a four-story wooden building of joist construction. The sprinkler system had no alarm valves; there was no watchman's service, and the thermostat system failed to operate owing to a broken wire which was afterwards discovered. Fire started about two o'clock in the morning, probably from spontaneous ignition of oily waste. A policeman heard the water running, and saw the same coming out under the doors at 5.30 a. m. One head was operating under a pressure of thirty-five pounds, and fire was extinguished. There was no fire loss. Water loss of $4,850 resulted.

12640. Fire started in the early morning in a drawer of stitching machine, from the spontaneous ignition of oily rags contained therein. One sprinkler operated under a pressure of eighty pounds and extinguished fire. Alarm valve connected to thermostat system operated promptly and notified the fire department. The latter had a half-mile run to make, but shut off water at once on their arrival. Owing to a large quantity of white uppers near and underneath the sprinkler that operated, a water loss of $8,598 resulted.

1833. Fire occurred in third story from spontaneous ignition of cutting board scrapings. Floors were light boards on joist. One head operated under a pressure of thirty pounds and extinguished fire. Thermostats were so spaced that the sprinkler operated first and cooled it down, so that an alarm was not given by that source. The system was fortunately provided with an alarm valve, and although considerable water damage resulted before system was shut off, a much heavier loss was undoubtedly averted. Fire damage, $50; water loss on stock, $6,500.

1919. Viscolizing was done in the basement. An employee had completed his work, and had drawn the viscol from tank and was about to pour it back into a barrel. As it was dark, he struck a match in order to see when can was full. The bung hole of barrel was open; a flash resulted and barrel exploded. Twenty sprinklers operated under a pressure of sixty-two pounds and extinguished the fire. A water loss of about $30,000 resulted.

2740. An employee was dragging a metal can containing rubber cement along the floor, and contents became ignited probably from a

match on the floor. Fire occurred near a frame dry room and spread to this. Five sprinklers under ceiling and two inside of dry room operated under a pressure of sixty to eighty pounds with an automatic pump as supply. Water ran for about twenty minutes and about 5,000 gallons were discharged, doing a damage of $2,500.

5776. Fire occurred on top floor of factory early in the evening, due to spontaneous ignition of cutting board scrapings. Sprinkler system provided with an International lever check connected to outside electric gong. One head operated under a pressure of sixty-five pounds, but the alarm valve probably failed, for the running water was not noticed until midnight, when the factory was visited by the engineer for the purpose of starting up the boilers. It was estimated that 10,000 gallons of water were discharged. Loss on building, $250; water loss on contents, $6,500.

5852. The wax pot on a Goodyear stitching machine on fifth floor had a gas jet placed under it to help out the steam in heating the wax. Regular workman at machine was called away, and temporary man, not knowing that a gas jet had been installed, left it burning at night. Wax became ignited when water boiled away, and four heads operated under a pressure of eighty-five pounds and extinguished the fire, which did a damage of $25. The water passed through to the basement and did a damage of $5,200.

8189. Fire occurred on top story, due to spontaneous ignition of cutting board scrapings. Three sprinklers operated under a pressure of twelve pounds for half an hour, practically extinguishing the fire. Firemen used a chemical under a table. There was practically no fire loss, but a water damage of nearly $10,000 resulted.

8373. Fire occurred on seventh story of eight-story brick joist constructed tenant shoe factory having floors of double seven-eighths inch boards. Cause, spontaneous ignition of cutting board scrapings. Three sprinklers operated under a pressure of ninety pounds and practically extinguished the fire. Automatic alarm was received promptly, and firemen shut water off in about ten or fifteen minutes. There was practically no loss by fire, but a water loss of $4,500 resulted.

12860. Fire occurred in a waste chute of an eight-story tenant factory. The iron door on sixth floor was not properly fastened. A rush of hot air pushed the door open and the sprinkler head just inside the room and immediately overhead was opened. The loss, amounting to $4,829, was all done by water and would have amounted to nothing had the iron door to waste chute been properly secured.

5637. Fire occurred in factory of brick mill construction, on fourth floor, used as a cutting and stitching room. Cause, probably spontaneous ignition of cutting board scrapings. Factory was equipped with Neracher sprinklers supplied by city water of good pressure and three sprinklers opened and extinguished the fire. Factory was equipped throughout with Watkins slotted cap thermostats connected to fire department and bell on building, and there was a sprinkler alarm valve. Neracher lever alarm check

connected to the thermostat system. At about 8.15 p. m. a round of four strokes was received at the fire station over the automatic alarm circuit, this being the box number for the factory. Firemen stated there had been so many false alarms of one round that they paid no attention to the alarm and did not even investigate. Fire was not discovered until nine o'clock Sunday morning, when a passerby noticed water running out of the building. Three sprinklers must have operated for about twelve hours. The water damage was estimated at from $20,000 to $50,000. It was supposed that the sprinklers operated shortly after the thermostat and the cooling of the thermostat opened the circuit, so that only one round was sent in, and the sprinkler alarm probably failed entirely, being of an unreliable type.

This fire is an example of a large loss due to defective alarm service.

742. Fire occurred about 3.20 a. m. on top floor of factory from unknown cause. Four heads operated under pressure of eighty-eight pounds and extinguished the fire. Thermostats operated and bell was heard ringing at the fire department headquarters. A member went to the factory and investigated the annunciator. He claimed that the gong stopped ringing before he reached it and that there were two of the annunciator drops down, showing trouble in two buildings. He concluded that it was a false alarm and made no further effort to investigate the matter. An employee on arriving at about 6.30 in the morning discovered the water running. The loss was due entirely to water and was upwards of $25,000.

1511. Fire occurred from unknown cause on fourth floor. Four sprinklers operated under a pressure of forty pounds and extinguished the fire. Fire department was notified by alarm from public box and responded at once. The fire was practically extinguished, but a delay occurred in closing the gate valves because of the poor arrangement, there being a separate shut-off at street connection and under gravity tank, with no valve that controlled the system. A stock of leather was heavily damaged, amounting to $3,000.

9642. Fire occurred on fourth floor from unknown cause under a rack of partly finished shoes. Fire burned a hole about two feet square in floor and dropped to floor below, setting fire to shelves containing upper leathers, etc. No sprinklers nor thermostats operated on floor where fire originated, probably due to the fact that floor was thickly packed with shoe racks containing partly finished shoes, which served to keep the heat down. There is little doubt, judging from this fire, that shoe racks where they are so numerous and packed so closely together, as is the case generally in large shoe shops, form considerable obstruction to the quick operation of sprinklers and thermostats.

On the floor below where the fire originated, the greatest damage was done. Thermostats operated here properly and four sprinklers opened. The latter apparently extinguished the fire, although they were considerably hampered by the obstruction of the shelves on which the uppers were kept. The initial pressure of eighty-five pounds, however, overcame this to some extent. Fire department also used hand chemical extinguishers. Thermostats transmitted the alarm to the engine house promptly. Loss $7,293.

12834. Fire occurred on the third floor from unknown cause in a small box located under a sewing machine bench. Sprinkler system was provided with an alarm valve connected to fire department, and this operated promptly. One sprinkler operated under a pressure of eighty-four pounds and extinguished the fire. Fire loss amounted to $150. Although the floors were three-inch splined plank with top flooring, the water passed through building and a water loss of $8,600 resulted.

1481. Fire occurred on fifth floor in a barrel of rubbish and sweepings and worked its way into some bags of lasts which made it difficult for water from sprinklers to reach fire. Three sprinklers operated under a pressure of thirty-four pounds and held the fire in check. The fire department responded to automatic alarm and extinguished fire with chemical streams. It was necessary to close three valves in order to shut water off the sprinklers. Two of these were in basement and reached with difficulty. This fact, together with the use of chemical streams by the fire department, caused a considerable amount of water damage.

2360. Fire occurred on fifth floor in a small frame room which had a muslin and paper-covered ceiling. Fire started under a large unsprinklered shelf due to spontaneous ignition of rubbish and sweepings. The fire burned between the joist of the muslin and paper-covered ceiling and beyond reach of the sprinklers. Eleven sprinklers operated under a pressure of thirty pounds and held the fire in check. Public fire department notified by box alarm and extinguished fire with a hand chemical. A heavy water loss resulted.

6522. Fire started on top floor in a space between a closet and a hollow wood sheathed wall, situated in a dark corner of the room. The space opened into room but it was difficult to keep it clean and fire was caused by spontaneous ignition of rubbish and sweepings which had collected here. Watchman discovered fire, but owing to dense smoke which quickly formed he could not get near it, and sent in a public alarm. The firemen, thinking that a vigorous fire was underway, used two hose streams. Five sprinklers operated under a pressure of seventy pounds and held the fire in check. The use of the hose streams caused a water damage of over $5,000.

9754. Sparks from boiler stack set fire to shingle roof in several places. Employees working in attic discovered fire and gave the alarm. Before the fire department arrived, fire penetrated the roof in several places and eight sprinklers operated under a pressure of fifteen pounds. They held the fire from entering the building and fire on roof was extinguished by the use of hose streams. Fire did very little damage but water caused a loss of over $5,000.

9799. Fire started on third floor, caused by a kit lamp which had been left burning. One sprinkler operated under a pressure of forty-three pounds and held fire in check. Fire department responded to automatic alarm and extinguished blaze under the benches and hanging racks, where the sprinkler could not reach, with a chemical stream. The fire loss on the building was small, but the water damage was considerable, owing to the large amount of upper leather suspended from the ceiling. Loss about $6,000.

3781. Fire which occurred in an exposing unsprinklered box factory, set fire to this factory. Thirty-six sprinklers operated under an initial pressure of sixty pounds and prevented fire from spreading within.

3622. Fire occurred in an exposing unsprinklered one-story frame storage shed containing leather scrap. Factory was provided with a fairly good open sprinkler equipment against the exposure, but in the excitement which followed the discovery of the fire, the open sprinklers were forgotten and water was not turned on until fire had obtained a good foothold on wall of factory. When open sprinklers were finally turned on, they were of little value, for the fire department in the meantime fought the fire effectively with hose streams. Three sprinklers opened inside of factory, but no fire entered. A total damage of $11,000 resulted.

1226. Fire occurred from unknown cause under a packing bench at side of room where water from the sprinklers could not readily reach the fire, and it gained considerable headway. Shoe racks also interfered with proper distribution. Twenty-two heads operated under a pressure of twenty pounds and held the fire in check. The fire was discovered and public fire alarm rung by an outsider. Fire department responded promptly and fire was effectively handled by them. A loss of $6,000 resulted.

1418. Fire occurred on fifth floor in some bags and barrels of lasts from unknown cause. Five sprinklers operated under a pressure of sixty-five pounds and held fire in check. Public fire department assisted with fire engine hose and chemical streams. Building was damaged to the extent of $881 and a loss of $5,266 resulted on contents.

1869. This was a very quick exposure fire, due to the burning of a blacksmith shop eight feet from frame factory with unprotected windows. It would appear that the open sprinklers did excellent work, but the exposure was so near that the heat broke windows and opened twenty-seven sprinklers inside. The engineer was frightened by the smoke in building and knocked open some forty-four sprinklers. This was entirely unnecessary and greatly increased the loss.

11215. Fire started in or near a two-story and attic exposing frame tannery sixty feet away, with adjoining three-story and attic dry loft building. Owing to light construction of exposure, fire spread very rapidly, enveloping the whole building. Fire was first noticed by employee of shoe factory about 5.45 p. m., apparently leaping out of the building and coming right toward the factory. It was stated that smoke so rapidly filled the rooms that the employees had to grope their way out.

Factory was a four-story wooden building of mill construction, equipped with Grinnell glass button sprinklers, wet system, with an average of eighty-six heads on each floor. System was standard in every respect. Primary supply was waterworks, fifty-five pounds, and a 15,000-gallon gravity tank constituted the secondary supply. Open sprinklers were installed along the exposed side under the cornice, supplied by city water.

The engineer was immediately notified and he rushed to the open sprinklers. Windows were then cracking. Spectators said that the open

sprinklers did great service at first, but as the apparatus arrived (some seven steamers) the draught was so heavy that some one thought the water had been shut off and came in to see why. Employees went to the roof with pails and stayed around inside to aid in saving stock. Sprinklers operated freely and a stream from chemical engine was also used. A couple of hose streams were directed at factory at times. Owners stated that they kept asking for hose streams to be directed onto an unsprinklered storehouse, but department did not have the men to handle them. Later a stream was brought around the north side of factory, but storehouse was then practically destroyed. About two-thirds of the wall of main factory was badly burned and had to be replaced. There was no fire damage inside, owing to the effective work of the automatic sprinklers, but a heavy water damage resulted. The water pressure during the fire was probably thirty to thirty-five pounds and the gravity tank was nearly drained. Thirteen sprinklers opened on the first and second floors, thirty-eight on the third floor and fifty-four on the top floor. Total loss about $145,000, about half of which was due to loss of contents in unsprinklered storehouse.

Had there been a steamer connection on outside sprinkler system, or had this system been connected with the gravity tank, the outside sprinklers would perhaps have been entirely effective and prevented the tremendous water loss occasioned by the needless opening of so many sprinklers inside the factory.

10. POINTS OF INTEREST FROM FIRE REPORTS.

Alarm Service.

5425. Watchman in building, but regular rounds were not made. He made a round at 2 a. m. but discovered no evidence of fire. Alarm was given by thermostats and alarm valve at 4.11 a. m.

5606. The sprinkler operated first. The water chilled the nearest thermostat, causing an absolute failure of the thermostat alarm system.

Thermostats installed in standard manner with a thermostat at each sprinkler head are not liable to fail from such a cause.

11144. Owing to defective spacing of thermostats they failed to operate and sprinklers operated for two hours before discovery, hence an unnecessary heavy water damage was done.

3756. Thermostat failed to operate, probably sprinklers operated first, sprinklers being one foot nearer the fire. Thermostat may have been defective. They were the ether tube type.

3759. During a storm an electric light wire crossed a thermostat wire and this caused a fire inside of the building, at the same time putting the thermostat system out of service.

3624. Policeman in street heard thermostat gong on outside of building and rang in fire alarm box. Thermostat system failed to operate at engine house, owing to outside circuit being out of service.

3625. Mercury heat alarm thermostat failed to operate, probably due to defective spacing, thermostat being about fifteen feet apart across joists. Fire started in one of the channels and opened a sprinkler three feet away. Nearest thermostat about five feet away. Sprinkler probably opened first. Water rotary going on outside of building awoke bookkeeper, who lives about a quarter of a mile away. Fire was at three o'clock in the morning and the alarm undoubtedly saved what might have been a large loss.

3635. Thermostat bell on outside of building was heard ringing and one of the tenants called the fire department. Thermostat had not rung at the engine house, owing to the outside curcuit being out of order.

The fires enumerated above show the necessity of approved thermostat systems with central station connections and efficient maintenance service.

7759. A thermostat alarm was received at fire department station while the department was out, but the bell soon stopped ringing, An outsider there happened to hear it and notified the firemen, stating he thought, however, that the fire was out. The captain, nevertheless, went to the factory and found a brisk fire in waste chute, which was just entering factory through a door that had been left open.

The interest and efficiency of this fire department official was an example of the type of men that happily are controlling many of our fire departments to-day.

9022. Fire broke out twelve minutes after watchman passed in the vicinity where it started. He became aware of the fire by the operation of the rotary gong. Thermostats transmitted alarm to fire department. Owing to the presence of the watchman, the water was promptly shut off, the fused head replaced, and the system put in order, with a minimum water loss before the firemen arrived.

This occurrence demonstrates the necessity for automatic alarms in sprinklered plants and also the desirability of maintaining a capable man on premises who need not necessarily make regular rounds to be efficient in time of need.

Construction.

6805. There was a brick waste chute extending from the boiler room up to all floors, built into one of the pilasters of the brick wall. The ten by twelve floor timbers supported by this pilaster were exposed on their ends to the inside of the chute. Waste material which had lodged about the end of one of the timbers ignited spontaneously and the timber was burned off.

2489. Fire occurred in a supply closet with closed top and no sprinklers inside. The closet and contents were consumed.

Sprinklers should have been inside the closet.

3490. Fire was mainly back of the sheathing and sprinklers could not entirely extinguish it. Water was allowed to run from two sprinklers from

one to two hours to make sure the fire was out. This caused considerable water damage.

Sheathing should not be used and should be removed wherever possible.

2987. Fire got into joist channels and sprinklers could not entirely extinguish it.

Joist construction is inferior, from any point of view, to good plank and timber construction.

Gate Valves.

1486. Heavy water damage owing to difficulty closing sprinkler shut-off valve.

1511. Excessive water damage caused by delay in closing sprinkler valves.

1871. Three valves had to be closed to shut off water from sprinklers, delay causing heavy water damage.

3452. The firemen did not shut off the water until the three valves which controlled water supply to sprinklers had been found. Owing to the poor arrangement of sprinkler valves this took considerable time.

3458. Probably less water damage would have resulted if the sprinkler system had been arranged so that one valve could have shut off both supplies.

3758. It appears that the sprinkler ran about three-quarters of an hour before shut off, and thereby did considerable water damage. The night fireman at the factory was a new man and did not know the location of the valves.

11930. There was considerable delay in shutting off the water, owing to complicated valve arrangement.

10218. Two heads operated and promptly extinguished the fire. A 10,000-gallon pressure tank was nearly exhausted because the night engineer and watchman were not familiar with the controlling valves.

12077. One sprinkler opened during the noon hour and immediately extinguished the fire. The water ran for several minutes, doing considerable damage, as no one present at the time knew how to shut off the water. The engineer who had charge of the system was hastily summoned from his dinner.

All sprinkler valves should be plainly labeled and a sufficient number of foremen instructed in their location to insure the presence of someone informed at all times.

10648. Fire department was notified of fire by automatic alarm. Fire had been extinguished by the operation of one sprinkler when they arrived. They were, however, unfamiliar with the location of valves, and had to

hunt up an employee to do this, which took three-quarters of an hour, and resulted in considerable water damage.

12859. Considerable time was spent by the fire department in finding the location of sprinkler valve, and an unnecessary water loss resulted.

8592. Fire was promptly extinguished by the operation of one sprinkler. Firemen quickly responded to thermostat alarm. The firemen spent some time in locating the main valve, then went to the tower over the top floor and shut off the tank supply, putting the whole system out of service. Had they been familiar with the sprinkler equipment, they could have shut off a valve on floor where fire occurred, thus saving much needless water damage.

It is imperative that the fire department co-operate with the owners of sprinklered properties and familiarize themselves with the whole sprinkler system, but more especially with the location and arrangement of all controlling gate valves.

3614. Fire department responded quickly to the alarm of fire. The sprinklers had practically extinguished the fire before their arrival, so they at once shut off the water and prevented a considerable water damage.

It may be noted that the fire department of this city acts very quickly and efficiently in closing sprinkler valves, satisfying themselves first, however, that the fire is out and then running for the main valves, with the positions of which they are familiar. Other departments might easily profit by their example.

Hazards.

4394. The next day after the fire, bags of leather scrap that had been wet down were removed. In so doing it was noted that some were steaming hot from the heat of slow combustion that had been caused by the spontaneous ignition of the wet scrap. Part of this scrap was patent leather, and it was thought that the lampblack and other ingredients in this were the basis of the spontaneous ignition.

Wet leather, especially patent leather and scrap, should be cared for at once after a fire, if it has been subject to water damage.

4866. As a result of two fires which occurred in quick succession in the same property, due to the fact that young ladies had formed the habit of heating coffee and concocting hot lunches, it was forcibly demonstrated that this had become a real hazard. Fire resulted from the ignition of naphtha fumes nearby, of which the young ladies had not thought or had carelessly overlooked.

Employees should be strictly prohibited from heating lunches, etc., except at such time and place as may be acceptable to the management and free from danger.

9902. As the result of a fire caused by the careless ignition of naphtha that was being used from an open can, the management ordered at once the installation of approved safety benzine cans.

11299. Rubber cement being used from an open pan, ignited by the presence of an unprotected light.

The frequency of such fires forcibly demonstrates the danger of having open gas jets near a cement-using process and of cement being used in open receptacles.

5416. Stitching machine in the making room provided with gas jets to heat the wax pots on the machines. Gas was left burning at night, wax boiled over and ignited, setting fire to surrounding material.

Wax pots should be heated by steam wherever practicable. If gas is used it should not be lighted until operator of machines are at their places, and gas should be shut off at night by a master valve in charge of a responsible employee charged with that duty.

12084. A wooden last fell from a shelf and struck a match. The spark thus produced ignited the vapor from a last dip consisting of naphtha, paraffin, glycerine and white chalk, in which the heels and toes of lasts were dipped to make it easier to pull the stock off from the lasts.

12922. The buffing dust from pounding-down machines collected on roof and ignited spontaneously. The buffing wheels were located on the first floor and the dust was discharged in an iron dust collector box outside of the building, below the level of the machines. The air relief pipe extended up the outside of the building. The buffing dust, when very dry, often ascended the vent pipe and collected on the roof.

This hazard was obviated by placing a sprinkler in the vent pipe just above the dust box, which operated continuously, thus wetting the buffing dust and making it too heavy to rise.

Inside Protection.

9902. Fire occurred during working hours and in presence of employees, due to upsetting of an open can of benzine. Four sprinklers operated before any inside protection could be found. Fire was extinguished, but considerable water damage resulted.

Owners at once installed twelve approved chemical extinguishers.

10516. Fire occurred in a can of rubber cement. This fire demonstrated that sand pails were most efficient means of combating such a fire.

Lighting.

9727. Kerosene oil lamp used for heating tree iron, was being filled while it was burning. It was probable that employee carelessly used naphtha instead of kerosene to fill lamp. The lamp flame ignited the vapors from the five-gallon filling can which was being used. In attempting to throw the can out of the window, it was upset and the burning oil flowed about the room.

Obstructions to Distribution.

11250. Fire occurred in a closet on a shelf due to spontaneous ignition of an oily buffing wheel. A heavy linoleum top to closet prevented the sprinklers which operated from quickly extinguishing the fire.

29. The need of placing sprinklers under tables and benches was clearly demonstrated.

2368. Fire started at floor under a large unsprinklered shelf and gaining headway gradually followed a wooden partition and post to the muslin and paper covered ceiling, where it got between joists and beyond the reach of the sprinklers. The sprinklers, handicapped as they were by obstructions, held the fire so well in check that it was only necessary for the firemen to use a chemical stream on their arrival.

3634. Sprinklers did good work, except that they could not reach the fire which got between wood sheathing on the joists and floor above. Department had to cut holes through the floor above and fire was then extinguished by a stream from the chemical.

3759. Owing to obstructions to distribution from several partitions the sprinklers could not entirely extinguish the fire. It was several hours before fire was discovered and the water damage was considerable.

Operation of Sprinklers.

874. Had sprinklers been staggered, as required by the present rules, probably fewer number would have opened.

1266. Sprinkler spacing defective under open joist allowed fire to spread along joist channels.

1874. Sprinklers worked to a disadvantage as spacing was ten feet across joists, not staggered.

7193. A building was divided into two sections by a fire wall. On the fourth floor one section was heated and one section was cold. A small fire occurred on the floor of heated section near the door opening in fire wall. The section contained thirty-eight sprinklers, twenty-four of which operated. This unusual occurrence was explained by the fact that door between sections was opened and that the indraught of cold air banked up the heat at the end of the section away from the fire, causing many heads to operate before the heat became sufficiently intense to fuse the heads in the immediate vicinity of the fire.

Preventing Water Loss.

12779. A small water loss was due to the rubber blankets which were kept over the upper stock at all times.

The desirability of keeping on hand by all manufacturers a supply of waterproof covers, where using stock which is susceptible to water damage, was practically demonstrated.

Steamer Connection.

2472. Fire was in a large livery stable twelve feet away, and exposing window openings had no protection. A sprinkler equipment had been

placed in the shoe factory. Equipment was not quite completed and had not received approval, but the fire department used the steamer connections, pumping into the equipment and preventing the fire from entering the building. Fifteen sprinkler heads in all opened. The fire loss to building consisted of the burning out of several of the window frames, and the loss to the interior of the building and to the stock was by water only and was not serious.

Type of Sprinklers.

3636. Sprinklers held fire in check, but distribution was not satisfactory, owing to poorly designed deflector. Some delay in shutting off water, owing to the tank connection at top of system, which necessitated the closing of two gate valves.

Miscellaneous.

2074. This was an excellent example of good standard sprinkler protection under heavy water pressure and also good alarm service. One sprinkler entirely extinguished the fire.

1596. High test heads in boiler room failed to open. One low test head opened in factory.

1919. Match ignited a barrel of viscol, which exploded, making a quick, hot, fire and opening up a large number of sprinklers.

11. NUMBER OF SPRINKLERS OPENED.

No. of Sprinklers Operating.	Extinguished Fire. No. of Fires.	Extinguished Fire. Per Cent.	Held Fire in Check. No. of Fires.	Held Fire in Check. Per Cent.	Unsatisfactory. No. of Fires.	Total. No. of Fires.	Total. Per Cent.	No. of Sprinklers Operating.	No. of Fires.	Per Cent of Whole.
1	176	63	25	35	1	202	55	1	202	55
2	46	16	18	25	..	64	18	2 or less	266	73
3	26	9	4	5.5	..	30	8	3 or less	296	81
4	15	5	..	..	..	15	4	4 or less	311	85
5	3	1	8	11	..	11	3	5 or less	322	88
6 to 9 inc.	5	2	9	12	..	14	4.5	Less than 10	336	92
10 to 24 inc.	9	3	4	5.5	..	13	3.5	Less than 25	349	96
25 to 49 inc.	1	..	2	3	..	3	1	Less than 50	352	97
50 and over	..	..	2	3	11	13	4	50 and over	13	3
Total....	281		72		12	365				

Average number of sprinklers opened, not including unsatisfactory, 3.14.

12. ALARM SERVICE.

	Satisfactory. No. of Fires.	Satisfactory. Per Cent.	Failure. No. of Fires.	Failure. Per Cent.	Total.
Watchman alone	9	90	1	10	10
Sprinkler alarm alone	24	96	1	4	25
Thermostat alone	62	76	20	24	82
Supervisory	1	100	..	..	1
Total	96		22		118

Efficiency of Alarm Service, 1897-1910, Inclusive.

	Watchman.		Sprinkler Alarm.		Thermostat.		Supervisory.		Total.
	Satisfactory.	Failure.	Satisfactory.	Failure.	Satisfactory.	Failure.	Satisfactory.	Failure.	
Watchman and sprinkler alarm	13	6	17	2	..	..	..	..	19
Watchman and Thermostats	1	2	..	..	3	..	..	..	3
Sprinkler alarm and Thermostats	63	10	..	..	49	24	..	..	73
Watchman, Sprinkler Alarm and Thermostats	1	6	6	1	5	2	..	..	7

Note.—These tables do not include fires where alarm service does or does not operate properly if fire is at once discovered by employee, the alarm service having no bearing on such fires one way or the other.

13. SECONDARY WATER SUPPLIES.

According to the reports, in only four fires, other than those plants that were totally destroyed, was the secondary water supply to sprinklers called into service, and in these cases it is probable that the results would have been practically the same had there been no second supply.

1266. Primary water supply, 4,500 gallon pressure tank, giving eighty pounds pressure on sprinklers which opened. Second supply, city water giving forty to fifty pounds pressure. Five sprinklers opened. Spacing was somewhat defective under open joists, so that fire spread some along joist channels and was not at once extinguished. Pressure was reduced until city water came into service. By that time it is probable that the fire department was completing the extinguishment of the fire, so that it is more than likely that the results would have been the same had there been the pressure tank only. The second supply was in this case of service in maintaining a heavy pressure on sprinklers.

5510. Primary supply, waterworks which gave a static pressure of sixty pounds on the sprinkler which operated. A 5,000-gallon gravity tank was half drained. City water was shut off at once on arrival of fire department, leaving tank in service. Sprinkler held fire in check.

11157. Primary supply, waterworks which gave a normal pressure of ten pounds on the four sprinklers that operated. Second supply consisted of a 4,800-gallon gravity tank, which gave a pressure of nine pounds. Waterworks pressure was probably immediately reduced below the tank pressure, and gravity tank was undoubtedly a factor at start of fire, as 800 gallons of water were in operation, and raised the pressure to seventy pounds. Sprinklers extinguished the fire.

11218. Detailed account given under Large Loss Fires Where Action of the Sprinklers Was Satisfactory.

14. EFFICIENCY OF WATER SUPPLIES TO SPRINKLER SYSTEMS.

Primary Water Supply.	Number of fires	Per cent. of fires	Average pressure	Average number sprinklers opened	Per Cent. of Fires.			Average Pressure.			Average Number Sprinklers Opened	
					Extinguished fire (or practically extinguished)	Held fire in check	Unsatisfactory	Extinguished fire (or practically extinguished)	Held fire in check	Unsatisfactory	Extinguished fire (or practically extinguished)	Held fire in check
Waterworks,	288	79.0	61	3.0	59.2	17.3	2.5	63	56	49	2.0	6.6
Gravity tank,	21	5.7	26	4.5	4.4	0.5	0.8	28	24	18	3.2	15.0
Pressure tank,	50	13.7	90	3.4	12.0	1.6	..	92	75	..	2.9	7.3
Automatic pump,	6	1.6	72	2.3	1.4	0.3	..	73	68	..	2.6	1.0
Total,	365	100.0	63	3.14	77.0	19.7	3.3	65	57	41	2.2	6.8

15. EFFICIENCY OF WATER PRESSURES ON SPRINKLER SYSTEMS.

Pressure on Sprinklers.	Number of fires	Per cent. of fires	Average pressure	Average number sprinklers opened	Per Cent. of Fires.			Average Pressure.			Average Number Sprinklers Opened	
					Extinguished fire (or practically extinguished)	Held fire in check	Unsatisfactory	Extinguished fire (or practically extinguished)	Held fire in check	Unsatisfactory	Extinguished fire (or practically extinguished)	Held fire in check
Less than 15 lbs.,	9	2.6	11	2.1	1.9	..	0.5	11	..	12	2.1	..
15 to 24 inclusive,	10	2.8	18	6.9	2.2	0.5	..	18	18	..	4.9	15.0
25 to 49 inclusive,	103	27.8	39	3.9	19.2	7.7	1.4	38	38	33	2.0	8.5
50 and over,	243	66.8	77	2.7	53.7	11.5	1.4	79	71	61	2.2	5.3
Total,	365	100.0	63	3.14	77.00	19.7	3.3	65	57	41	2.2	6.8

16. EFFICIENCY OF WET OR DRY SPRINKLER SYSTEMS.

Wet or Dry System.	Number of fires	Per cent. of fires	Average pressure	Average number sprinklers opened	Per Cent. of Fires.			Average Pressure.			Average Number Sprinklers Opened	
					Extinguished fire (or practically extinguished)	Held fire in check	Unsatisfactory	Extinguished fire (or practically extinguished)	Held fire in check	Unsatisfactory	Extinguished fire (or practically extinguished)	Held fire in check
Wet system,	346	94.8	64	2.9	72.6	18.9	3.3	67	58	41	2.1	6.4
Dry system,	19	5.2	45	6.4	4.4	0.8	..	46	35	..	4.4	16.7
Total,	365	100.0	63	3.14	77.0	19.7	3.3	65	57	41	2.2	6.8

Note—"Average number of sprinklers opened" does not in any case include the Unsatisfactory fires.

17. EFFICIENCY OF WATER SUPPLIES TO SPRINKLER SYSTEMS — As Regards Amount of Loss.					Per Cent. of Fires.			Average Pressure.			Average Number Sprinklers Opened.		
Primary Water Supply.	Number of fires	Per cent. of fires	Average pressure	Average number sprinklers opened	No claim	Small loss	Large loss	No claim	Small loss	Large loss	No claim	Small loss	Large loss
Waterworks,	288	79.0	61	3.0	12.9	58.1	7.9	69	60	50	1.5	2.2	4.2
Gravity tank,	21	5.7	26	4.5	2.7	1.9	1.1	29	19	18	2.1	5.4	22.0
Pressure tank,	50	13.7	90	3.4	4.4	7.9	1.4	95	89	85	1.7	4.3	3.4
Automatic pump,	6	1.6	72	2.3	1.4	..	0.3	71	..	80	1.4	..	7.0
Total,	365	100.0	63	3.14	21.4	67.9	10.7	69	63	52	1.6	2.6	12.3

18. EFFICIENCY OF WATER PRESSURES ON SPRINKLER SYSTEMS — As Regards Amount of Loss.					Per Cent. of Fires.			Average Pressure.			Average Number Sprinklers Opened.		
Pressure on Sprinklers.	Number of fires	Per cent. of fires	Average pressure	Average number sprinklers opened	No claim	Small loss	Large loss	No claim	Small loss	Large loss	No claim	Small loss	Large loss
Less than 15 lbs.,	9	2.6	11	2.1	1.4	0.3	0.8	12	10	12	1.6	4.0	3.0
15 to 24 inclusive,	10	2.8	18	6.9	..	2.2	0.6	..	19	18	..	4.9	15.0
25 to 49 inclusive,	103	27.8	39	3.9	2.7	21 6	3.8	36	39	36	1.8	2.8	14.4
50 and over,	243	66 8	77	2.7	17.3	43.8	5.5	79	77	73	1.6	2.4	11.1
Total,	365	100.0	63	3.14	21.4	67.9	10.7	69	63	52	1.6	2.6	12.3

19. EFFICIENCY OF WET OR DRY SPRINKLER SYSTEMS. — As Regards Amount of Loss.					Per Cent. of Fires.			Average Pressure.			Average Number Sprinklers Opened.		
Wet or Dry System.	Number of fires	Per cent. of fires	Average pressure	Average number sprinklers opened	No claim	Small loss	Large loss	No claim	Small loss	Large loss	No claim	Small loss	Large loss
Wet system,	346	94.8	64	2.9	20.0	64.6	10.2	71	63	53	1.6	2.3	12.3
Dry system,	19	5.2	45	6.4	1.4	3.3	0.5	42	48	33	1.0	7.7	11.5
Total,	365	100.0	63	3.14	21.4	67.9	10.7	69	63	52	1.6	2.6	12.3

Note—"Average number of sprinklers opened" does not in any case include the Unsatisfactory fires.

GENERAL FIRE RECORD.

Unsatisfactory or Serious Fires in Buildings Equipped with Sprinklers.

Where sprinklers fail the cause is, almost invariably, clear. These fires are selected to indicate such causes, that they may be generally understood and satisfactorily met.

13265. Saw Mill. Lath and Shingle Manufacturing.

Construction and Occupancy of Buildings Involved. Saw Mill. Part two, part three stories in height, 46 x 196, metal clad on skeleton wood frame; sides and ends generally open in first story, ends only open in second story, earth and plank floor in first story, heavy open joisted construction elsewhere, all interior woodwork painted or whitewashed, metal roof direct on wood joists on skeleton wood frame. Stairs open in all stories.

Lath Mill. Adjoining north end of west side of saw mill, two stories, 20 x 56, same construction as saw mill.

Assorter Shed. Detached 16 feet east of saw mill; one story, 20 x 85, open sides and ends, metal roof on wood joists on skeleton wood frame supported on wood trusses on wood columns. All interior woodwork whitewashed or painted.

Power House. Detached 10 feet west of saw mill, but connected to same by open all metal refuse conveyor to boiler house, and by all steel belt covering to engine room. Boiler house one high story, engine room one story and basement, 40 x 75 over all, brick 13-inch walls on north, east and south sides, all parapetted three feet above roof. West side, metal clad on skeleton wood frame. Engine room separated from boiler house by light frame partitions. Concrete floor in basement of engine room and in boiler house. All steel and iron charging floor in boiler house over dutch ovens in front of boilers. Single plank floor on wood joists in first story of engine room. Roof of metal on wood joists on skeleton wood frame on wood trusses. No protection over openings for belt and refuse conveyor. Opening in south wall of engine room protected by standard metal clad three-ply wood core fire doors on one side of wall. Door was of self-closing sliding type, held open by weight with fusible link in weight cord; link arranged to be always in the opening for any position of door.

The third story portion of the saw mill was located near the south end of the mill, was 43 x 46 feet and was used as saw filing room. The second story of the mill was used for sawing logs into timbers and boards and for cutting slabs into laths and shingles. The first story of mill contained shafting and belting for operating machinery in second story and was also used for hogging refuse and bundling shingles.

Fire Protection of Plant. Casks of water and fire pails were distributed throughout the plant. Watchman on duty nights only, using Newman approved portable clock with twelve stations, well arranged to cover buildings and lumber yard.

There were two 3-inch standpipes in saw mill with 1½-inch hose connection on each in each story. Fifty feet 1½-inch linen hose and small nozzle attached to each hose connection. Standpipes supplied through four-inch connection from underground hydrant and sprinkler mains, each connection being controlled by post indicator gate valve located well away from buildings.

The boiler house and engine room were fully equipped with a standard wet-pipe system of Grinnell glass valve sprinklers with Grinnell variable pressure alarm valve in riser, connected to operate water motor gong on west side of building. The saw mill was fully equipped with a standard dry-pipe system of Grinnell glass valve sprinklers. The equipment was divided into two systems, each being supplied by a five-inch riser equipped with five-inch Grinnell straightway dry-pipe valve with connection from intermediate chamber of each to water motor gongs on west side of saw mill building.

Outside screw and yoke gate valve under each dry-pipe valve in mill and under alarm valve in boiler house. The sprinkler protection was complete, sprinklers being installed in all closets, bins, small enclosures, and under all decks, platforms, stairs, in monitors and under assorter table, as well as under roof of assorter shed. Each sprinkler riser was supplied through an independent connection controlled by post indicator gate valve, from underground hydrant and sprinkler mains.

The sprinkler system was modern in all respects, having been installed in 1910.

There were two standard hydrants on the west side of the mill, each having two 2½-inch hose connections with independent valves. Standard hydrant house erected over each with 150 feet 2⅝-inch cotton rubber-lined hose and 1⅛-inch nozzle play-pipes in each house.

The automatic sprinklers, inside standpipes and outside hydrants were supplied by a 25,000 gallon gravity tank on 90-foot tower, tank having eight-inch down pipe and a 750-gallon Underwriters' steam fire pump with ten-inch suction pipe to river and eight-inch discharge. Pump and tank were properly checked against each other. The underground mains were of eight and six inch pipe supplying the hydrants, sprinklers and standpipes and extended along the west side of the buildings only, plugged ends being left to continue the mains around the mill and install hydrants on all sides at some future date.

Cause and Extent of Fire and How Fought. The fire started in the saw filing room from unknown cause about 4.25 a. m. and was fought with two hose streams from outside hydrants as well as the inside automatic sprinklers.

The saw mill and assorter shed were a total loss and the power plant was damaged about ten per cent, the damage being principally to the roof, the main belt and the electric generator.

The Watchman's Story of the Fire. The watchman stated that he started on the last round he made the night of the fire at 3.57 a. m., making his entire round as usual and finding everything all right, returned to the office at about 4.15 and was sitting on the gallery. Said his attention was attracted by the whistling of ferry boat and went out into the open space beyond the office to investigate. He saw fire at what he supposed was the east side of the filing room in the third story of mill and started for the machine shop. Arriving at the machine shop he told the night fireman to get out the hose as he (the watchman) didn't know anything about the hose and he would fire the boiler.

The watchman was questioned at length and the following facts were brought out. He had only been employed as a watchman for about a month and knew practically nothing about saw mills and machinery, he having been previously employed in the woods and was brought in to watch the plant. Watchman stated that he had not been instructed in the use or handling of any of the fire apparatus and no rules or instructions had been given him to follow in case of emergency or fire. He further stated that he didn't know how to couple hose or operate the hydrants, also that while he was on his way to the mill after having heard the whistle of the ferry boat he heard some bells ringing and the night fireman blew the whistle on the machine shop as an alarm of fire. He noted the steam pressure on dinkey boiler on each round and it was being maintained at 40 pounds. No instructions had been issued to the watchman to raise steam on main battery of boilers in case of fire and none of the fifteen or twenty men who responded to the alarm suggested that steam be raised on the main boilers.

The superintendent stated that he was at home at the time of the fire. He was notified over the telephone by the owner that the mill was on fire, and went with him to the plant. They arrived about six o'clock a. m., and at that time the fire was confined to the river end of the mill in the second story, and the automatic sprinklers were working perfectly, and were holding the fire in check, but in addition to the sprinklers the men about the plant were fighting the fire with hose streams. He stated the fire was apparently under control, and was being gradually extinguished, when at about eight o'clock a. m. the check valve on the injector for the dinkey boiler either clogged with mud or broke, and this boiler had to be put out of commission for about three-quarters of an hour, while the injector check valve was being put back into commission. The pump was shut down during this time, and the tank water having been exhausted, the fire spread, getting beyond control, and soon the heavy machinery, in

falling from the upper story, wrecked the sprinkler system inside the mill, so that when the pump was again started the sprinkler system was of no value, the post indicator valves in yard having to be closed in order to save the water for use through the outside hydrants.

The superintendent stated that at time of fire the two systems in the mill were being maintained dry, and the alarms were operative. It was stated that the sprinkler worked perfectly, and this statement seems borne out by the fact that the fire in the sawmill was held in check for four hours, or until the pump had to be shut down from inability to furnish steam with a broken injector on the boiler, and also from the fact that the power plant, only a few feet distant, was damaged only about ten per cent. Sawmills which are not sprinklered are subject to quick fires, and would probably be a total loss in an hour.

Conclusions.

The extent of this fire was not so much due to a failure of the sprinkler system, as it was to faults of management.

The watchman's service at this plant appeared to have been very poor, a watchman being employed who, by his own statement, didn't know how to couple hose. This man was employed by the management to watch the property at night, the plant being in his charge practically fifty per cent of the day. The management certainly was at fault in leaving the property in the care of a man of this ability without instructing him in the use of the fire apparatus, and giving him strict rules to follow in case of emergency. The records showed that the watchman made a round of the plant every hour. That is, the records showed that he consumed from fifteen to twenty minutes patroling the lumber yard and mill buildings, and spent the remainder of every hour on the office steps or at his home, a few steps from the office. The watchman should have consumed from forty to forty-five minutes making his round, and rested the remainder of the hour. According to the watchman's record, and making allowance for the clock being ten minutes fast, the watchman registered from the station in the saw filing room about 4.10 a. m., or about fifteen minutes before the fire was discovered by the crew of the ferry boat.

The failure of the management to instruct those left in charge of the plant as to what to do in case of emergency or fire is probably the direct cause of the fire getting beyond control of the sprinklers. It is confidently believed that if no hose streams had been used on this fire, the sprinklers would have extinguished the fire in a comparatively short time, but with the reduced volume and pressure of the water (owing to the hydrants being open), which supplied the sprinklers, the sprinkler system was considerably handicapped, but did remarkably good service in holding this fire in check for four hours, till the pump had to be shut down on account of a broken boiler feed. The breaking of an injector or an accident to same is liable to happen at any time, but the necessity of having to shut down the fire pump on account of a broken injector was entirely unnecessary. Instructions should have been given the night watchman and night fireman to raise

steam on the main battery of boilers as soon as possible, in case of emergency. Even in the absence of these instructions there was ample time to raise steam on these boilers after the arrival of the superintendent at six o'clock, as the injector on the dinkey boiler didn't fail till about eight o'clock. If steam had been raised on the main battery of boilers the breaking of the injector on the dinkey boiler would not have made it necessary to shut down the fire pump, and let the fire get beyond control.

Summary: Inefficient watch service and incompetent handling of the fire protection installed.

The lessons to be drawn from this fire are, first, that the employing of an ignorant man for a watchman, and letting him rush through the plant in a few minutes, and spending the most of his time at the office, does not constitute reliable and efficient watch service; and, second, that when fire protection is installed instructions should be given as to the proper handling of same in case of emergency.

13022. Woodworker. Manufacturing Carriage Stock. At 12.25 p. m. the fire department was called to a fire in the westerly end of a hay shed fifteen feet to the south of this building. Two engines were placed at the hydrant south of the hay shed, and about midway of its length. At the middle section of the shed near this hydrant a fire occurred about a week previously, and the doors were wide open to dry the hay. Hay was also thrown out into the driveway to the south near the hydrant. This had been exposed to the hot sun for several days, and must have become quite dry. It is said by employees that they saw sparks from the fire engines set fire to the hay in the driveway, and immediately flash into the shed. The engineers sounded their whistles to attract attention, but there was some delay in getting a stream on the fire, as the men were busy at the end of the shed putting out the first fire.

A three-story frame sprinklered building divided into two sections by a good brick fire wall was badly damaged by this exposure fire, and the automatic sprinkler equipment proved inadequate. The sections were about 45 by 160 feet and 45 by 125 feet in area. Floors and roof were plank and timber. Roof was tar and gravel. Finish was open.

The north, south and west ends of the building were equipped with Grinnell open sprinklers, shovel type, at the cornice, about eight feet apart, over the head of each line of windows. These sprinklers were turned on when the first fire started. Eye witnesses say that the fire flashed across the hay shed with great rapidity, carried by a strong southwest wind.

The sprinkler system was an old one, with 1-3-6 schedule of pipe sizes installed in 1886, but the heads were Grinnell glass disc installed in 1895. A single four-inch riser near the fire wall in the east section fed the sprinklers in both sections on the second and third floors, and all but eight or nine sprinklers of the 312 on the system operated. A separate four-inch pipe fed the sprinklers on the first floor and basement, and only about eleven sprinklers opened here. The fire entered the several stories at the same time, thereby overtaxing the sprinkler system. On the top story about one half was burned. On the second floor damage was about the same.

On the first floor little or no fire got into the building beyond the exterior wall. Of the exterior wall, about one hundred feet in length next the hay shed was damaged.

The water curtain was turned on the north side of the building after the fire had passed the curtain on the south side, and through the building, so as to prevent the spread of the fire to the property at the north. While the sprinklers and water curtain did not prevent the fire from entering the building, there is no doubt that it was their action that prevented a total loss and a probable spread to the nearby property.

The fire in the hay shed was located so as to straddle the fire wall, and set fire to both sections of the building at the same time. This brought double duty on the sprinkler system, and the fact that sprinklers were opened on two floors at once (not counting the few opened on the first floor) also doubled this duty, so that the system was called upon to do four times the work for which it was designed.

Loss to building was about thirty per cent; loss on contents will be much higher.

Summary: Heavy exposure fire.

13074. Cotton Warehouse. A grass fire which got beyond control set fire to warehouse about three p. m. This was of joist construction, and equipped with automatic sprinklers supplied by city water at sixty pounds pressure. There were fifty-four heads in the room, and all opened, but the water was shut off at the time. When they were turned on the fire was so well under way that they proved ineffective. Fire was fought with hose streams supplied by city water and steam pump. It was estimated that 60,000 gallons were used from the city supply, and 40,000 gallons by the pump. A loss of about $7,000 resulted.

Summary: Water shut off.

12871. Foundry. An electrician's room of joisted construction, about 40 ft. x 16 ft., was located on the core oven roof, and adjoined and opened into the monitor on the foundry roof. It was accessible by stairs at the south end of the foundry, and was occupied for electrical repairs and storage of electrical supplies in wooden racks and bins.

A dry-pipe sprinkler system had been completed in the foundry, and was connected to a new yard system. There were no sprinklers in the electrician's room. This had not been included in the contract. The yard system was supplied by a Knowles 1,000-gallon Underwriter pump, taking suction from the six-inch city main through a six-inch National meter. A 50,000-gallon gravity tank had been erected, but was not connected, and there was no pressure on the yard system at the time of the fire. The protection was in the hands of the contractor.

The fire was burning briskly when discovered by the crane man in the foundry. The mill fire brigade had on streams before the arrival of the public department. The indicator posts controlling the sprinklers in the foundry were opened soon after, but it was found that so many sprinklers had been opened that the water supply was inadequate, and the sprinklers were shut off after about ten minutes' trial. Loss about $7,000.

Summary: Unsprinklered portions.

12783. Automobile Factory. At about 7.15 p. m., three hours after the mill had shut down, the watchman noticed water coming from under the carpenter shop door. He unlocked the door and found the room full of smoke. Being unable to determine the extent of the fire, he immediately turned in a public alarm of fire. This was done from one of the regular watchmen's stations, all of which registered at a central office.

The three sprinklers which had opened failed to extinguish the fire which had started under a lumber rack. The watchman used a small hose stream, and the fire department used one large stream and extinguished the fire. The room, however, was flooded with water, which wet down some kiln-dried lumber and some exhibit furniture which was under construction. The fire destroyed 400 feet of lumber on the rack and two tables which were nearly completed.

Some of the furniture was being finished with linseed oil and turpentine, and as very little work of this kind had been done in the carpenter shop, no receptacles for the oily rags had been provided. The owners stated that these rags were removed every night, but it seems probable that, due to the absence of proper receptacles, some of them may have been overlooked, and may have caused the fire by spontaneous ignition.

Summary: Obstructions to distribution.

12927. Coke Works. Fire occurred in the crusher building. This was equal to four stories in height, of heavy timber construction with corrugated iron siding and shingle roof. Upper part of building contained four large bins or hoppers with a total capacity of 1,000 tons of crushed coal. Bins were made of heavy plank and were supported by timber frame of building. West of crusher building was a wooden trestle and unloading shed for cars of coal, with hoppers between the rails, conveying coal to crushing machinery below the trestle. After crushing, coal was carried to top of crusher building by a conveyor enclosed in wood. Coal was then either dumped into bins or carried through to another conveyor and then direct to ovens.

On the day preceding fire a quantity of coal was taken from a reserve stock kept in yard, and run through the crusher and then into the bins. This coal was probably "hot" having been in the pile for a long time and it is thought to have caused the fire.

The failure of the sprinklers was probably due to the fact that the fire burned through the planking and supports of the bin in which it started, which gave way under the weight of the contents and broke down the sprinkler pipe supplying the overhead sprinklers, cutting off the water supply. Three city engine companies and the owner's private yard hydrant and hose system were used to extinguish the fire. The upper half of the building was entirely destroyed, together with contents of bins and conveyor and machinery. No damage to other buildings on the premises. Loss about $10,000.

Summary: Sprinkler system crippled.

Fire-Resistive Buildings---Fire Record

These fires are selected to illustrate the behavior of various forms of fire-resistive construction under exposure to fire from within or without.

S-12908. Pulp Board Mill. Construction. Machine building was a basement and one-story building of reinforced concrete construction except the roof which consisted of plank on wooden trusses covered with Carey roofing. The window frames and sashes were of wood. A wood and plaster gallery, or runway, the ruins of which are shown in Fig. 1, was built along the side of the mill. The floor, roof and frame were of wood, the sides being cement plaster. The stone used in the concrete was coarse grained crushed granite. The sand was of good quality and the work was carefully done. The placing of the steel was said to have been done better than the average.

Stock house was a one-story building built with concrete piers, supporting a wooden floor carried on steel beams, with wooden columns carrying a plank and timber roof covered with tar and gravel. The walls of the building were "hy-rib" metal. The shipping building was a basement and one-story building of wood, open joist construction.

S-12908.

Fig. 1. View of Pulp Mill after Fire. Burned gallery on opposite bank parallel to river.

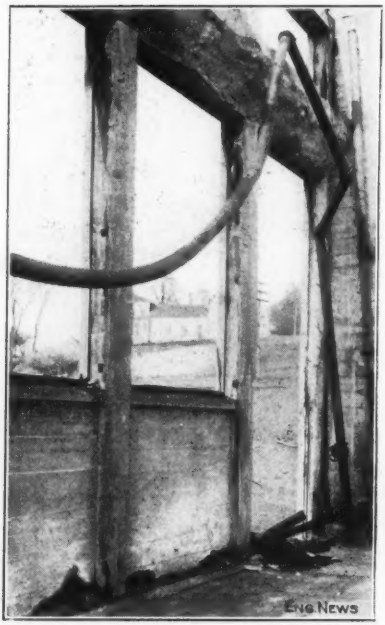
S-12908.

Fig. 2. View of Column and Under Side of Floor after Fire.
Note exposed rods in girder.

Occupancy. The machine building contained a large board machine and finished stock on the first floor. Pulp and waste paper were stored in the basement. In all, there was a large quantity of dry pulp board piled inside the building at time of fire. The stock house contained pulp. The shipping building contained pulp in the basement and finished stock on the first floor.

Protection. Esty sprinklers were installed throughout the first floor of machine building and shipping building. There were no sprinklers in the basement of these buildings, in the runway at the side of machine building, nor in stock house. Primary supply consisted of waterworks which gave a static pressure of fifty pounds on the sprinklers that operated. Secondary supplies consisted of a 16,000-gallon gravity tank, a 750-gallon Deane Underwriter steam pump and a Fales and Jenks 750-gallon rotary pump.

Course of Fire. At 11 p. m. an employee at work in the basement of the machine room building discovered fire running over bales of waste paper. The alarm was given by blowing the mill whistle and the help responded promptly. The fire spread rapidly over the machine room building basement and out through the windows, setting fire to the covered



S-12908.

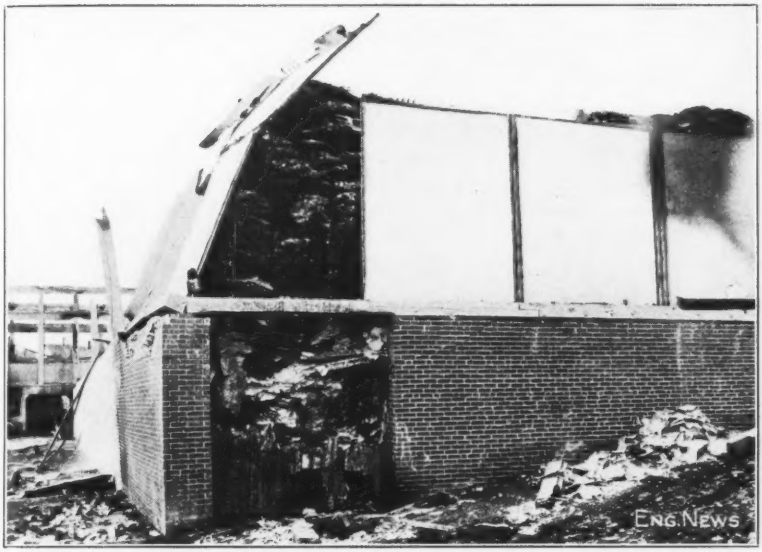
Fig. 3. Spalled Crane—Rail Girder.

passageway on the south side which ran to stock house. This stock house was quickly on fire and much of the pulp being dry, very soon the whole building and its contents were burning. From here it passed to the shipping building. This wooden joisted building attacked by fire from the basement below and from the stock house, soon collapsed in spite of the sprinklers under the roof. A three-inch sprinkler pipe broke and bled the supply to sprinklers in the machine room building. After this the sprinklers near the easterly end had practically no water and the fire extended to the roof. Soon more of the sprinkler piping fell and after that the sprinkler system was useless.

The fire also passed by the way of the windows up to the wooden overhanging cornice of the machine room building, and soon the whole easterly half of the roof was burning. The hose streams used by the well organized private brigade were very properly concentrated near the center of the machine room building to cut off the fire at that point and save the rest of the plant. This was successfully done. Until the sprinkler pipe broke in the shipping building, no anxiety was felt regarding the roof of the machine room building. The unsprinklered passageway leading to the stock house was directly over the basement windows where the fire started, and the fire seems to have passed through it to the stock house very quickly.

Help was called from neighboring towns and at about 2 a. m. a steamer arrived, but by that time the stock house and shipping building were practically destroyed and it is thought that the mill fire brigade, with their hose streams supplied by the two pumps, had the fire under control before the steamer arrived. The rotary pump was run for twenty-four hours and the steam pump for forty-eight hours, both continuously and doing good service.

Effect of Fire on Reinforced Concrete Construction. The fire was so hot that it bent and partly melted cast iron. The streams of water were thrown onto the hot building with considerable force. This fire was, therefore, a particularly interesting test of the effect of fire on reinforced con-



S-12908.

Fig. 4. Far End of Burned Gallery, looking toward main mill.

crete. We are indebted to *Engineering News* for a detailed account of the effect of this fire on the concrete construction, together with the valuable illustrations which we are able to use, which were furnished them by the engineers who built the factory.

The fire started under the first floor in the middle of the building. The principal observable effect of the heat was to expand the floor and to cause a movement of the columns. An engineer reported that on the morning after the fire the end wall of the mill was observably out of plumb, and at that time the concrete was generally so hot that he could not bear his hand on it on the outside of the building. Later on, this wall drew back again to the perpendicular. A crack at one of the piers showed the effect of this movement on the outside wall where the size of the wall beam changed on account of the change in spacing of the columns. The cracks above and below the bracket of the column also seemed to indicate the longitudinal movement of the floor.

The same sort of expansion seemed to be indicated by the cracking of the columns at the sides of the building, which was probably caused by the movement of the floor laterally. These cracks occurred at both top and bottom of some of the columns. It was noticed that in the section of the floor at the wall end of the building, the main cracks ran longitudinally and were clearly marked, and that the cracks at right angles to the build-

ing were comparatively few. Where the floor span decreased next to the large girders which supported the paper machine, the cracks began to run at right angles and end with diagonal cracks which died away into the part of the floor which was not heated. It was suggested that the cracks at the wall end of the building which were parallel to the main girder occurred because of the unequal heating of the big mass of this girder and the thinner floor slab, causing unequal expansion of the two masses. A similar cause may have produced the crack along the wall beam.

Fig. 2 shows a detail of the column head and the spalling of the concrete under the girder steel. Fig. 3 shows the condition of the crane rail girder after the fire. The concrete was here spalled off about two inches in depth. Where the concrete was rich in mortar there was less damage than where it was stony, the mortar acting as a fireproofing to the aggregate. Where the fire was hot, the concrete was softened for an average of an inch, so that one could hack into it with an ordinary carpenter's hammer.

At the base of the stock house there were some brick walls in the condition shown in Fig. 4. The interesting feature of this particular building was that the foundation piers, which were subjected to high heat, were built of concrete rich in mortar. This concrete withstood the action of heat much better than did the granite concrete of the main mill.

Fire Causes.

The fires here given are selected to illustrate defects, either of construction or superintendence, in the classes of property indicated.

Boilers.

S-12808. Back Draught. Wood refuse in front of the boiler in a tenant woodworking plant ignited by a back draught from boiler. Refuse was fed directly to boiler from blower system. When furnace is full the trunk is removed and refuse blown onto the floor.

Automatic boiler feed should be so arranged that when it is necessary to cut the feed off from the furnace, the refuse will be blown to a standard shavings vault instead of on the boiler room floor in front of furnace.

S-12700. Dirt on Boiler. Fire occurred in one story boiler room of a woodworking plant among dust and rubbish on top of boiler, and was caused by overheating of dust.

The top of boilers should always be kept scrupulously clean and never used for storage or drying purposes.

H-7755. Hot Ashes Against Woodwork. Fire occurred in the boiler room of a steam laundry near the floor where the metal sheathing of wall had been turned back to install a pipe leading from the bottom of

boiler to the outside of building. This opening of the metal sheathing exposed the woodwork of the wall. The floor in front of boiler was cement, but there was no ash pit and hot ashes were drawn out on this floor and carelessly allowed to come in contact with the exposed woodwork.

If the ashes had been properly taken care of, this fire would not have occurred. The woodwork should not have been allowed to remain exposed.

S-12796. Stack. An overheated boiler stack in a furniture factory set fire to woodwork around it.

Where stacks pass through roof an air space should be provided for and protection arranged in a manner similar to that illustrated and described in the October, 1911, Quarterly, page 157.

S-12803. Uptake. Fire occurred in a theatre, due to the ignition of a wood ceiling from heat radiated from the unprotected boiler uptake which passed within six inches of the ceiling.

There should be a clearance of not less than thirty-six inches between an unprotected boiler breeching and a combustible ceiling. If the breeching is protected by three inches of asbestos cement, or its equivalent, the space may be reduced to eighteen inches.

Lighting.

S-12832. Candle. Workmen were putting new floors in elevator of a wholesale dry goods house. A man was under the elevator floor and had a candle for light. In some way he tipped the candle over against the very greasy guide rail of elevator. Flame ignited the greasy and dirty accumulation on this guide rail and fire traveled up the rail to fourth floor.

Portable electric lights should find favor for work in similar dark places. There is no excuse for the further use of candles for such purposes.

Matches.

S-13675. Match Stepped Upon. Employee in a garage stepped on match which set fire to floor saturated with kerosene, and to rack used for the cleaning of tools, etc., with kerosene.

S-12678. Careless Disposal of Matches. Workman who was painting and varnishing a partition in a tenant manufacturing building lighted a cigarette and threw match into pail of filler.

S-12674. Careless Use of Matches. Employee in a tenant mercantile building lighted match to examine label on roll of belting, and burlap wrapping caught fire.

The above fires illustrate the common dangers incident to the use of matches.

Oily Material.

S-12797. Oily Overalls. A pair of oily overalls which were hanging on a wall ignited spontaneously.

Overalls should either be hung in the open where they will receive sprinkler protection, or else in standard metal lockers. They should never be rolled up nor thrown down carelessly on the floor or in some corner.

Power.

H-7670. Gas Engine. Fire started in wood, metal-clad wall of engine house of a grain and feed mill, where gasolene engine exhaust pipe passed through.

Exhaust pipes whether direct from engine or from mufflers should be provided with ventilated thimbles at least six inches larger in diameter than the pipes, where passing through partitions or wooden walls.

H-7794. Rubbish and Sweepings. Fire occurred at the base of a ventilating shaft in a fireproof hotel, due directly to the accumulation of inflammable material, which was ignited either by the dropping of a lighted match or cigarette from one of the windows, or by defective electric wiring.

Rubbish, etc., should be carefully excluded from the foot of light and ventilating shafts and similar places. Any unavoidable accumulation should be removed every night.

Smoking.

S-12935. Pipe in Workman's Pocket. Fire occurred in the coat room of a tannery. Room had good metal lockers throughout, but also had rows of wooden arms along low partitions, with hooks on which workmen hung their wet clothing at night. A hot pipe was evidently left in a coat hung on one of these hooks. Fire caused a loss of $7,500.

S-12819. Pipe. Workman in a cereal mill left a hot pipe in his coat pocket. About an hour later his coat, which was hanging on a wall, took fire and communicated the fire to the wall.

It is essential that workmen's clothing be kept in approved lockers, or under conditions of ample sprinkler protection.

S-12896. Careless Disposal of Cigar Stub. Fire caused by a cigar stub placed on an umbrella stand, which fell into an umbrella and ignited it.

S-12666. Lighted Cigarette Thrown Away. Fire occurred in fine wood dust under wood lathe power machine in a woodworker, due to lighted cigarette carelessly thrown.

Points of Interest from Fire Reports.

These notes are intended to illustrate the efficiency or inefficiency of signaling, retardant or extinguishing agencies.

Alarm Service.

S-12893. Alarm Valve. Fire occurred in the evening on the top floor of a tenant manufacturing building. It was apparently promptly extinguished by the operation of six sprinklers. The failure of an old lever check alarm, however, allowed a damage of $46,000 by water to take place. Was not discovered until water entered an adjacent building and was discovered by the watchman in the latter.

H-7946. Unused Watchman's Stations. Fire occurred in a packing plant and had been burning for sometime in an accessible place before the watchman discovered it. Plant was provided with forty A. D. T. stations, but for some unknown reason the watchman was not reporting on them.

Had the watchman been making his rounds regularly, there is little doubt that he would have discovered the fire promptly.

Automatic Sprinklers.

S-12697. Corroded Heads. Fire occurred under a sorting table of woolen clipping establishment and spread into a frame enclosed elevator shaft. Thirty-six heads operated. The operation of the sprinklers was undoubtedly slow, due to heads being more or less corroded.

Heads subjected to corrosive gas should be protected by some approved method, frequently examined and replaced by new heads when necessary.

S-13231. Location of Gate Valves. Fire occurred in a basement kitchen of the hotel section of a tenant building. Two sprinklers opened and promptly extinguished the fire. Night man who was present, through his lack of knowledge of the sprinkler system and the absence of signs locating the valves, was unable to stop the flow of water. The fire department had no better knowledge of valves and closed all valves in sight, including two domestic supply valves, one steam valve, main tank valve and floor control valve.

The moral of this occurrence is obvious. The purpose of all valves should be clearly indicated.

Construction.

S-13018. Concealed Spaces. Fire occurred in a concealed space or blind attic of a cupola on a drum and wooden horn works, due to a stroke of lightning. This space was unsprinklered. Owing to the difficulty of reaching the fire, seven fire engine streams were used, and a considerable water damage was done before fire was extinguished.

Had this concealed space been equipped with automatic sprinklers, as had been recommended to the owners, the loss would undoubtedly have been slight.

S-13232. Concealed Spaces. Fire occurred in a blind roof space of joist construction, eighteen to twenty inches deep, over the carpenter shop of a sugar refinery. Five sprinklers within operated and extinguished the fire.

This fire demonstrated the value of automatic protection in concealed spaces.

H-7672. Height of Buildings. The spread of the fire through the upper floors of the two fireproof tenant manufacturing buildings, both horizontally and vertically, especially by way of the interior court windows, was possible largely on account of the inability of the fire department to promptly attack it at such a height, especially in view of the deficiencies in the standpipe equipments.

The height of fireproof buildings should be limited by the adequacy of the fire protection, both public and private.

Fire Doors and Shutters.

H-7946. Non-Automatic Steel Fire Doors. Fire occurred in a packing house. Door openings in fire division walls were protected by steel doors which were not automatic. Doors which were subject to the fire, in the cases where they were not found open, were so badly warped by the heat as to be of little service.

Nothing but a standard automatic fire door should be allowed at door openings in fire walls.

H-7672. Fire Shutters. Most of the shutters used in the tenant manufacturing buildings involved were open, and were, moreover, deficient in their construction; the iron shutters had flat instead of angle iron frames, and the rolling shutters were mounted on wooden window frames on the inner side of the thin glass windows.

The common practice of leaving fire shutters open at night and on Sundays and holidays, and otherwise neglecting them, seriously adds to the conflagration possibilities. In view of this fact it would seem wise that the attention of firemen should be directed to shutters on exposed buildings promptly upon arrival at a fire. Where the exposure is not too severe, wired glass windows are preferable to shutters for the reason that they are almost sure to be closed, and can more readily be made to operate automatically.

Hose.

S-13025. Rubber Lined Hose. Fire occurred in a cocoanut oil refinery. Watchman tried to use a length of one and one-half inch rubber lined mill hose on reel, but no water would flow through it. Upon examination it developed that the cocoanut oil, which seemed to permeate everything on the premises, had saturated the cotton jacket, dissolved the cement and attacked the rubber lining, causing it to disintegrate. All of the hose at the plant was then examined and it was found that out of 600 feet inspected, 400 feet were in a similar condition, or approaching it. There were five or six brands represented and all showed the same weakness.

Linen hose only should be used in certain classes of industry where the rubber is apt to deteriorate owing to peculiar local conditions.

Inside Protection.

S-12977. Water Pails and Chemical Extinguishers. Fire occurred inside a mule in a cotton yarn mill. The employees in the room at the time opened the covers on mule carriage and immediately fought the fire with fire pails and chemical extinguishers. Fire was controlled before the automatic sprinklers had an opportunity to operate.

H-7672. Standpipes. Building, twelve stories, or 156 feet high, was provided with standpipes only two and one-half inches in diameter; wholly inadequate to furnish the number of hose streams desired.

The futility of constructing standpipes less than six inches in diameter in any building was clearly evidenced in this fire. In buildings over 150 feet high they should be eight inches.

H-7632. Standpipes. Fire occurred in an elevator well of a button factory. Employees used standpipe hose with good effect and had fire nearly extinguished upon arrival of fire department.

The value of suitably installed standpipe systems is repeatedly demonstrated.

Standard Rules and Requirements

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